DULUTH INTERNATIONAL AIRPORT
NEW PASSENGER TERMINAL
VOLUNTARY AIRPORT LOW EMMISIONS (VALE)
CONTRACT DOCUMENTS
ISSUED FOR BID

FAA AIP No. - 3-27-0024-51-11
RS&H PROJ. No. – 213.1882.110
CITY OF DULUTH BID No. 11-4402

PROJECT MANUAL
VOLUME 3 OF 4

Date: JUNE 9, 2011

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PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes general administrative and procedural requirements for mechanical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1:

1. Submittals.
2. Coordination drawings.
3. Record documents.
4. Maintenance manuals.
5. Codes, Permits and Inspections.
6. Separation of Work Between Trades.
7. Definitions and Interpretations.
8. Sustainable Building Submittal Requirements.
9. Utility Company Rebates
10. Operating Instructions
11. Guarantees and Certifications
12. Rough-In
13. Mechanical Installations
14. Cutting and Patching
15. Site Visitation Surveys and Measurements

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 15.

B. Division 15 Section "BASIC MECHANICAL MATERIALS AND METHODS," for materials and methods common to the remainder of Division 15.

C. This section is a part of each Division 15 Section.

1.3 APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

A. Minnesota State Building code (MBC)

B. Air-Conditioning and Refrigeration Institute (ARI)

C. American National Standard Institute (ANSI)

D. Air Moving and Conditioning Association (AMCA)

E. American Society of Mechanical Engineers (ASME)

F. American Society for Testing and Materials (ASTM)

G. National Fire Protection Association (NFPA)

H. American Association of Balancing Contractors (AABC)

I. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)

J. American Welding Society (AWS)

K. Cooling Tower Institute (CTI)

L. Environmental Protection Agency (EPA).

M. National Environmental Balancing Bureau (NEBB).

N. National Electrical Code (NEC)

O. Occupational Safety and Health Administration (OSHA).

P. Underwriters Laboratories (UL).

1.4 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and as specified in Division 1 Section "SUBMITTALS."

B. Prior to purchasing any equipment or materials, a list of their manufacturers shall be submitted for review.

C. Prior to assembling or installing the work, the following shall be submitted for review:

1. Scale drawings indicating insert and sleeve locations.

2. Scale drawings showing all piping and duct runs with sizes, elevations and

appropriate indication of coordination with other trades. This submission to us shall consist of one sepia and 2 paper prints.

3. Catalog information, factory assembly drawings and field installation drawings as required for a complete explanation and description of all items of equipment.

4. Coordination drawings for access panel and door locations.

5. Shop drawings detailing fabrication and installation for supports for mechanical materials and equipment.

6. Mechanical Contractor shall submit complete MER sheet metal and piping shop drawings to the AC unit manufacturer prior to submission to the Engineer. The AC unit manufacturer shall approve the air performance and acoustical performance of the AC units in the location and with the ductwork and piping configuration and construction as indicated on the shop drawing. AC unit manufacturer shall indicate approval directly on the shop drawing.

7. Welder Certificates signed by Contractor certifying that welders comply with requirements specified under “Quality Assurance” in Section 15050.

D. Documents will not be accepted for review unless:

1. They include complete information pertaining to appurtenances and accessories.

2. They are submitted as a package where they pertain to related items.

3. They are properly marked with service or function, project name, where they consist of catalog sheets displaying other items which are not applicable.

4. They indicate the project name and address along with the Contractor's name, address and phone number.

5. They are properly marked with external connection identification as related to the project where they consist of standard factory assembly or field installation drawings.

E. Shop Drawing Review

1. The purpose of the review of shop drawings is to maintain integrity of the design. Unless the contractor clearly points out changes, substitutions, deletions or any other differences between the submission and the Contract Documents in writing on the Contractor's letterhead, approval by the

Engineer or Architect does not constitute acceptance. It is not to be assumed that the engineer has read the text nor reviewed the technical data of a manufactured item and its components except where the Vendor has pointed out differences between his product and the specified model.

2. It is the responsibility of the contractor to confirm all dimensions, quantities, and the coordination of materials and products supplied by him with other trades. Approval of shop drawings containing errors does not relieve the contractor from making corrections at his expense.

3. Substitutions of equipment, systems, materials, temperature controls must be coordinated by the Contractor with his own or other trades which may be involved with the item, such as, but not limited to, equipment substitutions which change electrical requirements, or hanging or support weights or dimensions.

4. Any extra changes or credits which may be generated by other trades due to substitutions will not be accepted unless the Contractor has an agreement in writing with the Owner.

5. Substitutions of equipment, systems, etc. requiring approval of local authorities must comply with such regulations and be filed at the expense of the Contractor (should filing be necessary). Substitutions are subject to approval or disapproval by the Engineer. The contractor in offering substitutions shall hold the Owner and Engineer harmless if the substituted item is an infringement of patent held by the specified item.

F. Explanation of Shop Drawing Stamp

1. Approval indicates that we have not found any reason why this item should not be acceptable within the intent of the documents.

2. As Noted indicates that we have found questionable components which if corrected or otherwise explained make the product acceptable.

3. Resubmit indicates that this item should be resubmitted for approval before further processing.

4. Not Accepted indicates that the item will not meet the intent of the Contract.

5. No shop drawing stamp or note shall constitute an order to fabricate or ship. Such notification can only be performed by the Project Manager for Construction, the Contractor scheduling his own work, or the Owner.

1.5 COORDINATION DRAWINGS

A. Prepare coordination drawings in accordance with Division 1 Section "PROJECT COORDINATION," to a scale of 1/4" = 1'-0" or larger; detailing major elements, equipment components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of piping, ductwork, equipment, and materials. Include the following:

    (a) Planned piping layout, including valve and specialty locations and valve stem movement.

    (b) Planned duct system layout, including elbow radii and duct accessories.

    (c) Clearances for installing and maintaining insulation.

    (d) Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.

    (e) Equipment connections and support details.

    (f) Exterior wall and foundation penetrations.

    (g) Fire-rated wall and floor penetrations.

    (h) Sizes and location of required concrete pads and bases.

    (i) Clearances as required by Electric Code.

2. Indicate piping loads and support points for all piping 3" and larger, racked piping, and submit to the Structural Engineer for review and approval. Indicate the elevation, location, support points, and loads imposed on the structure at support, anchor points, and size of all lines. Indicate all beam penetrations and slab penetrations sized and coordinated. Indicate all work routed underground or embedded in concrete by dimension to column and building lines.

3. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.

4. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.

5. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communication systems components, sprinklers, and other ceiling-mounted items.

B. HVAC TRADE COORDINATION DRAWINGS

1. This Trade shall prepare Coordination Drawings showing all of the HVAC work (equipment, piping,, ductwork, conduit, etc.) To be installed as part of the work of this section of the specifications. The Coordination Drawings

shall be on reproducible transparencies at not less than 1/4" = 1'-0" scale.

2. Requirements for vibration isolation and seismic restraints shall be shown on the coordination drawings by each trade.

3. This Trade after showing all of the HVAC work shall forward the reproducible Coordination Drawings to the Plumbing Contractor.

4. The sequence of coordination drawings shall be HVAC-PLBG-FP-ELEC-GC.

5. The HVAC Contractor shall attend a series of meetings arranged by the General Contractor to resolve any real or apparent interferences or conflicts with the work of the other Contractors or with ceiling heights shown on the architectural drawings.

6. The HVAC Contractor shall then make adjustments to his work on the Coordination Drawings to resolve any real or apparent interferences or conflicts.

7. After any real or apparent interferences and conflicts have been incorporated into the Coordination Drawings, the HVAC Contractor shall “sign-off” the final Coordination Drawings.

8. The HVAC Subcontractor shall not install any of his work prior to “sign-off” of final Coordination Drawings. If HVAC work proceeds prior to sign-off of Coordination Drawings, any change to the HVAC work to correct the interferences and conflicts which result will be made by the HVAC Contractor at no additional cost to the project.

9. Coordination Drawings are for the HVAC Contractor’s and Owner’s use during construction and shall not be construed as replacing any shop, “as-built”, or Record Drawings required elsewhere in these Contract Documents.

10. Review of Coordination Drawings shall not relieve the HVAC Contractor from his overall responsibility for coordination of all work performed pursuant to the Contract or from any other requirements of the Contract.

1.6 RECORD DOCUMENTS

A. Prepare record documents in accordance with the requirements in Division 1. In addition to the requirements specified in Division 1, comply with the following.

1. A complete set of "as-built" or record drawings shall be made up and delivered to the Architect.

2. The drawings shall show:-

(a) Ductwork mains and branches, size and location, for both exterior and interior; locations of all dampers and other control devices; filters, boxes, and terminal units requiring periodic maintenance or repair.

(b) Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Refer to Division 15 Section "Mechanical Identification." Indicate horizontal locations of underground piping.

(c) Equipment locations (exposed and concealed), dimensioned from prominent building lines.

(d) Approved substitutions, Contract Modifications, and actual equipment and materials installed.

(e) All "main air" pneumatic control piping routing locations must be shown.

(f) Updating of all equipment schedule sheets.

B. This trade shall submit the "as-built" set for approval by the building department in a form acceptable to the department, when required by the jurisdiction.

C. The drawings shall be produced using AutoCad 2000 or later software. The design drawings will be made available on disks in AutoCad format for use as a basis for the "as-built" drawings. These documents remain the property of Cosentini Associates and shall be used for no other purpose without expressed, written consent. The contractor shall assume all liabilities resulting from unauthorized use or modifications to the drawings. Prior to developing any "as-built" drawings, the contractor shall coordinate with the Owner and the Architect and Engineer the drawing layers, colors, etc., of the CAD drawings. "As-built" information shall be submitted as follows:

1. CAD drawing files on disks in AutoCad 2000 format.

2. One (1) set of reproducible drawings.

3. Two (2) sets of blueprints.

D. The quantity of design drawings which are made available shall in no way be interpreted as setting a limit to the number of drawings necessary to show the required "as-built" information.

E. Progress prints of record drawings shall be submitted monthly during the construction period for Architect's approval.

1.7 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1. In addition to the requirements specified in Division 1, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.

3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

4. Servicing instructions and lubrication charts and schedules.

5. List of spares: recommended for normal service requirements.

6. Parts list: identifying the various parts of the equipment for repair and replacement purposes.

7. Instruction books may be standard booklets but shall be clearly marked to indicate applicable equipment.

8. Wiring diagrams: generalized diagrams are not acceptable, submittal shall be specifically prepared for this project.

9. Automatic controls: diagrams and functional descriptions. (See control specification for additional requirements).

1.8 CODES, PERMITS AND INSPECTIONS

A. All work shall meet or exceed the latest requirements of all national, state, county, municipal and other authorities exercising jurisdiction over construction work at the project. These include, but are not limited to the following:

Minnesota State Building Code
NFPA National Fire Codes

B. All required permits and inspection certificates shall be obtained, paid for, and made available at the completion of the work.

C. Any portion of the work which is not subject to the approval of an authority having jurisdiction, shall be governed by the applicable sections of the overall National Fire Code, as published by the National Fire Protection Association.

D. Installation procedures, methods, and conditions shall comply with the latest requirements of The Federal Occupational Safety and Health Act (OSHA).

E. Prepare and submit to the building department a set of "as-built" record drawings for approval, in a form acceptable to the building department.

F. This Contractor shall prepare all plans, amendments and pay all filing fees that will be required for the fuel burning installation, including boiler plant, gas/oil fired chillers, chimney, oil piping, fuel oil tanks, gas piping, breeching, and any or all parts of the system under the jurisdiction of the controlling agencies.

G. This Contractor shall prepare all plans, amendments and pay all filing fees that will be required for the emergency generator installation, including oil piping, engine exhaust, fuel oil tanks, and any or all parts of the system under the jurisdiction of the controlling agencies.

H. This Contractor shall prepare all plans, amendments, and pay all filing fees that will be required for the electric generator and electric generator fuel oil tank installation.

I. This Contractor shall be responsible for the installation and filing until the installation has been approved by the authorities having such jurisdiction.

1.9 SEPARATION OF WORK BETWEEN TRADES

A. The specifications for the overall construction delineate various items of work under separate trade headings. The list below sets forth this delineation to the extent that it affects the HVAC work.

B. In the absence of more detailed information, this list shall be taken as a specific instruction to the heating, ventilating and air conditioning trade to include the work assigned to it.

C. Indications that the heating, ventilating and air conditioning trade is to perform an item of work mean that it is to perform the work for its own accommodation only, except as specifically noted otherwise.

D. Oth = Other than electrical or mechanical

Plb = Plumbing

Htg = Heating, Ventilating & Air Conditioning

Elec = Electrical

f = Furnished

i = Installed

p = Provided (furnished and installed)

ITEM	OTH	PLB	HTG	ELEC	NOTES
Motors for mechanical equipment.			p		
Motors starters and control devices for mechanical equipment. Heating:			p		Specifications and drawings delineate exceptions.
Power wiring for mechanical equipment motors.				p	Specifications and drawings delineate exceptions.

ITEM	OTH	PLB	HTG	ELEC	NOTES
Control wiring for motors. Heating:			 p		 Specifications and drawings delineate exceptions.
Wiring for automatic dampers. Heating:			 p		 Specifications and drawings delineate exceptions.
Temporary heat.	p				
Temporary water.	p				
Sealing of pressurized stairway, shafts and doors.	p				
Undercutting of doors and door louvers.	p				Supplying location where required included in HVAC.
Temporary light & power.	p				
Hoisting			p		
Rigging			p		
Cutting, chasing & patching	p				Cost where due to late installation or improper coordination of work is the responsibility of the delinquent trade.
Framed slots and openings in walls decks and slabs.	p				Coordination drawings are required from HVAC trade.
Sleeves through non-membraned slabs, decks and walls.			p		
Drilling & cutting of all holes in steel decks and precast slabs required for sleeves & supports.			p		
Sleeves through membraned slabs, decks and walls.			p		
Waterproof sealing of sleeves through membraned slabs, decks and walls.			p		
Fireproof sealing of excess openings in slabs, decks & fire rated walls.			p		

ITEM	OTH	PLB	HTG	ELEC	NOTES
Concrete encasement of underground runs			p		
Trenches in floor slabs	p				
Excavation and backfill inside buildings.	p				
Excavation and backfill outside buildings.	p				
Wells or openings in piping for pressure, temperature, flow, etc.			p		Wells and fittings furnished by Temperature Control subcontractor.
Keeping site and excavations free from surface water during construction.	p				To accommodate the overall project.
Fastenings			p		
Supports			p		
Steam manholes	p				Furnishing of covers, associated frames and other hardware included in HVAC trade.
Base flashing to all roof penetrations	p				
Roof vent and pipe cap flashing.			p		
Roof vent and base flashing.	p				
Roof curb cap flashing.			p		
Roof curb base flashing	p				
Concrete foundations, pads & bases inside buildings.	p				Furnishing of anchors and vibration mounts included in the HVAC trade.
Concrete foundations, pads & bases outside buildings.	p				Furnishing of anchors and vibration mounts included in the HVAC trade providing the associated equipment.
Field touch-up painting of damaged shop coats.			p		
Rustproofing field cut and assembled iron supporting frames and racks.			p		

Item	Oth	Plb	Htg	Elec	Notes
Finish painting of exposed work.	p				Insulation coatings are by HVAC trade.
Ornamental grills.	p				Duct connections included in HVAC trade.
Exterior wall louvers.	p				Duct connections & safing of all unused portions of louvers (2" thick insulated panel) is by HVAC Trade.
Finished wall and ceiling access doors, panels and supporting frames.	p				Supplying list locating all required access doors (none to be less than 16" x 16") included in HVAC.
Fire rated duct enclosures			p		
Thermal insulation for mechanical room ceilings.	p				
Flue Vents			p		Coordinate with Plumbing Contractor.
Convector enclosures.	p		p		
Catwalks to mechanical equipment.	p				Supplying list of locations where required included in HVAC.
Ladders to mechanical equipment other than cooling towers					Supplying list of locations where required included in HVAC.
Ladders to cooling towers.			p		
Ladders to roof mounted AC units and equipment.			p		Coordinate with Architect and Structural Engineer.
Steel dunnage for roof mounted AC units and equipment other than cooling towers.			p		Coordinate with Architect and Structural Engineer.
Gas service piping to heating boiler equipment.		p			Final connections included in heating, ventilation and air conditioning.
Domestic make-up water piping for heating and air conditioning systems.		p			Final connections included in heating, ventilation and air conditioning.
Control valves for domestic hot water heaters.		f	i		

Item	Oth	Plb	Htg	Elec	Notes
Walk-in refrigerator.	p				Line connections included in electric.
Laboratory and medical equipment.	p				line connections included in HVAC trade.
Rubbish removal			p		where one trade furnishes and another installs, the installing trade removes the shipping and packing materials which accumulate.
Special tools for equipment maintenance.			f		
Electric duct heaters (heaters installed in air ducts).			p		Line connections included in electric. Drawings delineate exceptions.
Electric heaters with integral fans (cabinet heaters, unit heaters and the like).			p		Line connections included in electric. Drawings delineate exceptions.
Electric radiators (baseboard, sill line, and convector type heaters).				p	
Through wall sleeve type air conditioning and electric heating units.			p		
Electric heater cables for radiant space heating.				p	
Electric heater cables for snow melting.				p	
Electric heater cables for pipe tracing.				p	Line and control connections and control device mounting included in electric.
Masonry shafts, sheet rock shafts, tunnels, utilized for air ducts.	p				This trade to assure the air tightness of all joints, holes and other openings to make these air conveyors acceptable for their function.

E. The Heating, Ventilating and Air Conditioning Trade is required to supply all necessary supervision and coordination information to any other trades who are to supply work to accommodate the Heating, Ventilating and Air Conditioning installations.

F. Where the Heating, Ventilating and Air Conditioning trade is required to install items which it does not purchase, it shall include for such items:

1. The coordination of their delivery.

2. Their unloading from delivery trucks driven in to any designated point on the property line at grade level.

3. Their safe handling and field storage up to the time of permanent placement in the project.

4. The correction of any damage, defacement or corrosion to which they may have been subjected.

5. Their field assembly and internal connection as may be necessary for their proper operation.

6. Their mounting in place including the purchase and installation of all dunnage supporting members and fastenings necessary to adapt them to architectural and structural conditions.

7. Their connection to building systems including the purchase and installation of all terminating fittings necessary to adapt and connect them to the building systems.

G. Items which are to be installed but not purchased as part of the work of the Heating, Ventilating and Air Conditioning trade shall be carefully examined by this trade upon delivery to the project. Claims that any of these items have been received in such condition that their installation will require procedures beyond the reasonable scope of work of the Heating, Ventilating and Air Conditioning trade will be considered only if presented in writing within one week of the date of delivery to the project of the items in question. The work of the Heating, Ventilating and Air Conditioning trade shall include all procedures, regardless of how extensive, necessary to put into satisfactory operation, all items for which no claims have been submitted as outlined above.

1.10 DEFINITIONS AND INTERPRETATIONS

A. Specific items of terminology, as used herein or on drawings, shall have the following meanings.

1. "Piping"----------------Pipe, fittings, flanges, valves, controls, hangers, traps, drains, insulation, vents, and items customarily required in connection with the transfer of fluids.

2. "Concealed"-------------Embedded in masonry or other construction, installed behind wall furring, within double partitions or hung ceilings, in crawl spaces, in shafts.

3. "Exposed"---------------Not concealed.

4. "By Other Trades" or "Others" or "Oth"-------By persons or parties responsible for work at the project other than the party or parties who have been duly awarded the contract for the work of this Trade. In the event that this document is used to acquire work as part of a general construction contract the words "by other trades" shall mean by persons or parties who

are not anticipated to be the sub-contractor for this trade working together with the general contractor. In this context the words "by other trades" shall not be interpreted to mean not included in the overall contract.

5. Where reference is made to N.E.M.A. Standards, it shall be understood that this reference is to the "Approved Standards", published by the National Electrical Manufacturers Association, Main Office - 155 East 44th Street, New York, New York 10017.

6. Where reference is made to "A.N.S.I. Standards", it shall be understood that this reference is to the standards published by the American National Standards Institute Incorporated.

1.11 INTERPRETATION OF THE DRAWINGS AND SPECIFICATIONS:

A. As used in the drawings and specifications, certain non technical words shall be understood to have specific meanings as follows:

1. "Furnish"-----------Purchase and deliver to the project site complete with every necessary appurtenance and support.

2. "Install"-----------Unload at the delivery point at the site and perform every operation necessary to establish secure mounting and correct operation at the proper location in the project.

3. "Provide"-----------"Furnish" and "Install".

B. Except where modified by a specific notation to the contrary, it shall be understood that the indication and/or description of any item, in the drawings or specifications or both, carries with it the instruction to furnish and install the item, regardless of whether or not this instruction is explicitly stated as part of the indication or description.

C. It shall be understood that the specifications and drawings are complementary and are to be taken together for a complete interpretation of the work. Where there are conflicts between the drawings and specifications or within the specifications or drawings themselves, the items of higher standard shall govern.

D. No exclusions from, or limitations, in the language used in the drawings or specifications shall be interpreted as meaning that the appurtenances or accessories necessary to complete any required system or item of equipment are to be omitted.

E. The drawings of necessity utilize symbols and schematic diagrams to indicate various items of work. Neither of these have any dimensional significance nor do they delineate every item required for the intended installations The work shall be installed, in accordance with the diagrammatic intent expressed on the electrical and mechanical drawings, and in conformity with the dimensions indicated on final architectural and structural working drawings and on equipment shop drawings.

F. No interpretation shall be made from the limitations of symbols and diagrams that any elements necessary for complete work are excluded.

G. Certain details appear on the drawings which are specific with regard to the dimensioning and positioning of the work. These details are intended only for the purpose of establishing general feasibility. They do not obviate field coordination for the indicated work.

H. Information as to the general construction shall be derived from structural and architectural drawings and specifications only.

I. The use of words in the singular shall not be considered as limiting where other indications denote that more than one item is referred to.

J. In the event that extra work is authorized, and performed by this trade, work shown on drawings depicting such work, and/or described by Bulletin is subject to the base building specifications in all respects.

1.12 CONTRACTOR'S RESPONSIBILITY REGARDING UTILITY COMPANY REBATE PROGRAMS

A. <u>This Contractor shall as part of his quotation for Base Bid work, include work in connection with Utility Company rebate programs as follows:</u>

1. For equipment which qualify for rebates from the Utility and which have been included in the Base Bid work as part of these specifications and/or the associated contract drawings, assist in the preparation of all applications, work sheets, and other documentation required by the Utility in order to insure their eligibility for rebate. In order to avoid possible loss of rebates, obtain written confirmation of eligibility from the Utility Company before placing orders for any such equipment. Schedule the filing of the documentation, the ordering of the equipment, and the installation of the equipment so as to guarantee compliance with all of Utility Company requirements. Notify the Architect in writing if these requirements will delay the building construction schedule.

1.13 SUSTAINABLE (LEED AND STATE OF MINNESOTA)

A. LEED Building Submittal Requirements

1. Contractor's Responsibility Regarding Rebate Programs, Tax Credits and Green Building Certifications

(a) This section applies to all projects in regard to available rebate programs but only requires adherence to the special programs listed when such programs are specifically called out to be part of the project. This Contractor shall as part of his quotation for Base Bid work, include work in connection with Utility Company, Local, State, and Federal rebate programs as follows:

(1) For equipment which qualify for rebates and which have been included in the Base Bid work as part of these specifications and/or the associated contract drawings, assist

in the preparation of all applications, work sheets, and other documentation required in order to insure their eligibility for rebate. In order to avoid possible loss of rebates, obtain written confirmation of eligibility from the agency offering the rebate and/or CM before placing orders for any such equipment. Schedule the filing of the documentation, the ordering of the equipment, and the installation of the equipment so as to guarantee compliance with all requirements. Notify the Architect in writing if these requirements will delay the building construction schedule.

(2) Contractor shall provide Owner assistance to meet the requirements of, the State of Minnesota Sustainable Buildign Guidelines (MSBG) and , the United States Green Building Council (USGBC) LEED™ New Construction Certification Program, Building Tax Credit (MSBG). This project must be in full compliance with the requirements of these programs. The Contractor is responsible to provide all information that is needed for the satisfactory demonstration of compliance as mandated in these guidelines. Compliance is required with all but not limited to the following:

(i) BUDGETING / COSTING

Contractor shall provide cost data from vendors and for their own work for all Energy Efficiency Measures (EEMs). Where guidelines provide alternative approaches to requirements such as the MSBG, the Contractor shall perform cost comparisons to assist the Owner and the design team in selecting the best option. Where guidelines require reporting of incremental cost differences between equipment and systems such as with the MSBG, the Contractor shall perform cost comparisons to assist the Owner in developing the required reports.

(ii) COMPLIANCE WITH REQUIRED PLANS FOR FIELD OPERATIONS

Contractor is responsible for compliance with all plans developed specifically for these programs as follows:

1) Erosion and Sedimentation Plan - This plan includes a description of all temporary and permanent erosion control and stormwater control measures implemented on the project

site and the type and frequency of maintenance activities required for the chosen erosion control methods. Compliance shall be monitored by a CM staff member regularly assigned to this task. A book including photographs of the site taken on a regular basis, forms for notification of non-compliance with the plan, and forms for noting the correction of non-compliant situations shall be maintained at the field office.

2) IAQ (Interior Air Quality) Plan compliant with MSBG and LEED. The plan should include specific actions and protective measure proposed for this particular site including descriptive narratives, detailed sketches, construction and pre-occupancy building flush, and Mold Mitigation program relative to the following requirements:

a) Electrical Protection

All electrical equipment must be protected from collecting not only dust but also, moisture and odors (which can "stick" to porous materials in the system and later be re-released). Bus duct and conduit are to be delivered to the site with ends covered. During construction and for all work in place, all open ends shall be covered.

b) Source Control

Contractors shall use products with low VOCs (Volatile Organic Compounds) and must use low sulfur fuels. This section also mandates field operating practices to reduce air borne contaminants and emissions.

c) Pathway Interruption

Pathway Interruption measures are required where areas are potentially subject to contamination from construction activities. Contractors as examples may be required to erect barriers to contain dust or relocate staging areas from air pathways or provide temporary sealing of intakes to avoid contamination.

d) Housekeeping

Specific actions shall be employed by all Contractors in regard to controlling contaminates at the work site.

e) Scheduling

Contractors must maintain schedules to ensure construction activity and building occupancy do not overlap in time. This also calls for a flush-out of areas to be occupied for two weeks with 100% outside air to remove any residual dust or odors from the space. Subcontaractors shall provide all standby labor required for this operation including a change of filters immediately after.

f) Sequence of Finish Installation

Finishes shall be sequenced to avoid porous materials absorbing emissions from wet-applied finishes. Contractors shall include appropriate allowances for drying or curing times of wet-applied finishes before installation of porous finishes and materials, based on technical specifications provided by the manufacturers.

g) Material Protection

Materials directly exposed to moisture through precipitation, plumbing leaks or condensation from HVAC equipment are susceptible to microbial contamination. The contractor shall take precautions necessary to protect materials installed or stored on-site from moisture damage and develop a Mold Mitigation program.

The project's designated Construction IAQ

Manager is responsible for implementation and enforcement of the Construction IAQ Management requirements and has the authority to implement stop work orders or termination of services for non-conformance with the requirements herein.

3) Construction Waste Management Plan - The rubbish removal plan shall provide for the handling and sorting of construction waste. Compliance with the plan is required by all Contractors

4) Pest Control Management Plan - In compliance with MSBG Guidelines this plan calls for the use of non-toxic pesticides and the use of boric acid for insect control. Compliance with the plan is required by all Contractors.

(iii) Minnesota Sustainable Building Guideline (MSBG) Submittal Requirements:

The Contractor and their sub-contractors shall submit the “MSBG” certification items listed herein. “MSBG” submittals shall include the following:

1) All completed “MSBG” Materials Certification Forms. Information to be supplied for this form shall include:

a) Cost breakdowns for the adhesives and sealants included in the Contractor or sub-contractor's work and listed under the “MSBG” PERFORMANCE CRITERIA in Section 16050 - Basic Electrical Materials & Methods. Cost breakdowns shall include total cost plus separate labor, equipment, and itemized material costs.

b) The VOC content of all adhesives, sealants, paints, and coatings applied on site as part of this work.

2) Product cut sheets for materials that meet the “MSBG” CERTIFICATION FORM. Cut sheets shall be submitted with the Contractor or sub-contractor's stamp, as confirmation that the submitted products are the products installed in the Project.

3) Material Safety Data Sheets (MSDS), for applicable products. Applicable products include, but are not limited to adhesives, sealants, carpets, paints and coatings. Material Safety Data Sheets shall indicate the Volatile Organic Compound (VOC) limits of products submitted (If an MSDS does not include a product's VOC limits, then product data sheets, manufacturer literature, or a letter of certification from the manufacturer can be submitted in addition to the MSDS to indicate the VOC limits).

4) Published product literature or letters of certification (on the manufacturer's letterhead) indicating the mercury content of each fluorescent lamp type installed.

5) The "MSBG" submittal information shall be assembled into one (1) package per Section or trade, and sent to the Consultant of review. Incomplete or inaccurate "MSBG" submittals may be used as the basis for rejecting the submitted products or assemblies.

(iv) Commissioning

Commissioning and training requirements shall be in accordance with the Commissioning specification section.

General Description of Roles:

A/E: Write requirements for start-up and pre-functional tests, perform construction observation, approve O&M manuals, respond to RFIs, clarify design intent and assist in resolving problems.

CA: Provide document reviews, coordinate the Cx process, write procedures and Commissioning Plan, oversee and compile documentation of pre-functional check lists, write functional performance tests for the commissioning plan, witness, in part, pre-functional tests, witness functional tests, comply results of Commissioning and training.

Mfr.: The equipment manufacturers and vendors provide documentation to facilitate the commissioning work, perform contracted startup, and participate in the proper operation of their equipment during functional and system testing, and training.
Subs: Assists in the preparation of all testing procedures, demonstrate proper system performance and provides all labor and testing apparatus required for start-up, functional and system testing, commissioning and training.

CM: Facilitates the Cx process ensures that Subs perform their responsibilities and integrates Cx into the construction process and schedule.

(v) Required Plans and Records for Sustainable/ Renewable Materials:

Submittals are to be reviewed by the Green and Sustainability Consultant to assure they include the required information for adherence to all programs. Subcontracts shall provide all data required to assure compliance.

(vi) Purchasing/Contracting/Record Keeping:

All Contractors, Material suppliers, and Vendors shall include the cost of supplying specified materials (mostly low VOC sealants, coatings, paints, carpet, insulation, etc.), specified by AA, in compliance with MSBG and LEED Guidelines. All Contractors shall include the cost of performing the installation of materials in accordance with details specified by AA, in compliance with LEED and BPCA, Guidelines.

2. Delivery, Storage, and Handling

(a) Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

(b) Unit shall be stored and handled in accordance with manufacturer's instructions.

(c) Unit shall be shipped with all listed items and control wiring factory installed unless noted on the submittals and approved prior to shipment.

(d) Unit shall be shipped complete as specified. Parts for field installation shall not be shipped and stored on site without prior approval.

(e) Rigging: Units shall be fully assembled. Units requiring disassembly for rigging shall be factory assembled and tested. Disassembly, reassembly and testing shall be supervised by the manufacturer's representative.

(f) Unit shall be shipped with firmly attached labels that indicate name of manufacturer, model number, serial number, and plan tagging.

(g) The Vendor shall shrink-wrap all electronic equipment and spare parts prior to shipping. Spare parts are to be delivered at time of owner acceptance.

3. Preconstruction Conference Prior to Start of Work

(a) Prior to commencing any Work, the CM, together with designated major Contractors, shall confer with the Architect and Engineer concerning the Work under the Construction Contract.

(b) The pre-construction conference will be conducted under the leadership of the CM and will occur soon after the CM notifies the Subcontractors of contract award. The pre-construction conference will focus on items such as the expedited submittal review procedure, interface and coordination between Contractor work scope, the CM's project site rules and requirements, temporary utility requirements, CM's construction schedule, etc.

B. Shop Drawing Review

1. The purpose of the review of shop drawings is to maintain integrity of the design. Unless the contractor clearly points out changes, substitutions, deletions or any other differences between the submission and the Contract Documents in writing on the Contractor's letterhead, review by the Engineer or Architect does not constitute acceptance. It is not to be assumed that the engineer has read the text nor reviewed the technical data of a manufactured item and its components including where the Vendor has pointed out differences between his product and the specified model.

2. It is the responsibility of the contractor to confirm all dimensions, quantities, and the coordination of materials and products supplied by him with other trades. Review of shop drawings containing errors does not relieve the contractor from making corrections at his expense.

3. Substitutions of equipment, systems, materials, temperature controls must be coordinated by the Contractor with his own or other trades which may be involved with the item, such as, but not limited to, equipment substitutions which change electrical requirements, or hanging or support weights or dimensions.

4. Any extra changes or credits which may be generated by other trades due to substitutions will not be accepted unless the Contractor has an agreement

in writing with the Owner.

5. Proposed substitutions shall be in accordance with the requirements of the section governing substitutions. Substitutions of equipment, systems, etc. requiring approval of local authorities must comply with such regulations and be filed at the expense of the Contractor (should filing be necessary). Substitutions are subject to approval or disapproval by the Engineer. The contractor in offering substitutions shall hold the Owner and Engineer harmless if the substituted item is an infringement of patent held by the specified item.

C. Explanation of Shop Drawing Stamp

1. Reviewed - No Exception Taken: indicates that we have not found any reason why this item should not be acceptable within the intent of the contract documents.

2. Exception Taken As Noted: indicates that we have found questionable components which if corrected or otherwise explained make the product acceptable.

3. Revised and Resubmit: indicates that this item should be resubmitted for review before further processing.

4. Resubmit Specified Item: indicates that the item will not meet the intent of the Contract.

5. Incomplete - Resubmit: Indicates that the submission is not complete and ready for review by the Architect or Engineer.

6. No shop drawing stamp or note shall constitute an order to fabricate or ship. Such notification can only be performed by the Project Manager for Construction, the Contractor scheduling his own work, or the Owner.

7. The Contractor is responsible for having "Reviewed" copies of shop drawings bearing the Reviewed - No Exception Taken stamp of the Architect/Engineer or Owner's Consultant are kept on the job site and work is implemented in the field in accordance with these documents.

8. Where information from one Contractor is required by another contractor, it is the responsibility of the contractors to exchange information and coordinate their work.

1.14 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 OPERATING INSTRUCTIONS

A. After all final tests and adjustments have been completed, fully instruct the proper Owner's Representative in all details of operation for equipment installed. Supply qualified personnel to operate equipment for sufficient length of time to assure that Owner's Representative is properly qualified to take over operation and maintenance procedures. Supply qualified personnel to operate equipment for sufficient length of time as required to meet all governing authorities in operation and performance tests.

3.2 GUARANTEES AND CERTIFICATIONS

A. All work shall be guaranteed to be free from leaks or defects. Any defective materials or workmanship as well as damage to the work of all trades resulting from same shall be replaced or repaired as directed for the duration of stipulated guaranteed periods.

B. The duration of guarantee periods following the date of beneficial use of the system shall be one year. Beneficial use is defined as operation of the system to obtain its intended use. For example, in the case of refrigeration systems, it means that the plant has a cooling load. Similarly, for all other systems.

C. The date of acceptance shall be the date of the final payment for the work or the date of a formal notice of acceptance, whichever is earlier.

D. Non-durable replaceable items such as air filter media do not require replacement after the date of acceptance. If received in writing, requests to have earlier acceptance dates established for these items will be honored.

E. Certification shall be submitted attesting to the fact that specified performance criteria are met by all items of heating and air conditioning equipment.

3.3 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 2 through 16 for rough-in requirements.

3.4 MECHANICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate mechanical systems, equipment, and materials installation with other building components.

2. Verify all dimensions by field measurements.

3. Arrange for chases, slots, and openings in other building components during

progress of construction, to allow for mechanical installations.

4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

5. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.

7. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.

9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

10. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

11. Install access panel or doors for maintenance or inspection where units are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section "ACCESS DOORS" and Division 15 Section "BASIC MECHANICAL MATERIALS AND METHODS."

12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

3.5 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Division 1 Section "CUTTING AND PATCHING." In addition to the requirements specified in Division 1, the following requirements apply:

1. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

B. Perform cutting, fitting, and patching of mechanical equipment and materials required to:

1. Uncover Work to provide for 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, uncover and restore Work to provide for Architect/Engineer observation of concealed Work.

C. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including but not limited to removal of mechanical piping, heating units, plumbing fixtures and trim, and other mechanical items made obsolete by the new Work.

D. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

E. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

1. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

(a) Refer to Division 1 Section "DEFINITIONS AND STANDARDS" for definition of "experienced Installer."

2. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

(a) Refer to Division 1 Section "DEFINITIONS AND STANDARDS" for definition of "experienced Installer."

3.6 SITE VISITATION SURVEYS AND MEASUREMENTS

A. Before submitting bid, visit the project site to satisfy yourself that all equipment shown or specified in the project contract documents can be installed generally as shown. Advise Owner prior to bid date, of any space or other installation problems.

B. Before submitting bid, become thoroughly familiar with all conditions under which work will be installed, as you will be held responsible for any assumptions, any omissions or errors made as a result of failure to become familiar with the site and Contract Documents.

C. Investigate each space through which equipment must be moved. Where necessary, equipment shall be shipped from manufacturer in sections of size suitable for moving through restrictive spaces available. Ascertain from building Owner at what time of day equipment may be moved through certain restrictive areas.

D. Install work so as to be readily accessible for operation, maintenance and repair. Minor deviations from drawings may be made to accomplish this, but changes which involve extra cost shall not be made without approval.

E. Removal and relocation of certain existing work will be necessary for the performance of the general work. All existing conditions cannot be completely detailed on the drawings. The Contractor shall survey the site and include all required changes in making up their bid proposal.

F. Submission of a bid shall be construed as evidence, that a careful examination of the portions of the existing building, equipment, etc., which affect this work and the access to such spaces has been made and that the Contractor is familiar with existing conditions and difficulties that will affect the execution of the work. Claims will not be allowed for labor, equipment or materials required because of difficulties encountered, which could have been foreseen during such an examination.

END OF SECTION 15010

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes the following basic mechanical materials and methods to complement other Division 15 Sections.

1. Piping materials and installation instructions common to most piping systems.
2. Fire and smoke Detection
3. Sequencing and scheduling
4. Access Doors in Finished construction.
5. Dielectric Fittings.
6. Pipe and Pipe Fittings.
7. Joining Materials
8. Piping Specialties
9. Labeling and identifying mechanical systems and equipment is specified in Division 15000.
10. Grout for equipment installations.
11. Drive Guards
12. Electrical Motors, Motor Controls and Wiring
13. Firestopping
14. Tools and lubricants
15. Dampers - General
16. Damper Terminal Strips
17. Automatic Control Valves - General
18. Piping Systems - Common Requirements.

19. Pressure Testing - All Piping Systems.

20. Equipment Installation - Common Requirements.

21. Labeling and Identifying

22. Painting and finishing.

23. Pans and Drains over Electrical Equipment.

24. Concrete Bases

25. Erection of Metal Supports and Anchorage

26. Welding procedure.

27. Excavation and backfill.

B. Pipe and pipe fitting materials are specified in piping system Sections.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and the Supplementary Conditions and Division 1 Specification Sections, apply to this and other sections of Division 15.

B. Excavation and backfill: Section 02200, EARTHWORK.

C. Section 03300, CAST-IN PLACE CONCRETE.

D. Section 05311, STEEL ROOF DECK.

E. Section 05321, STEEL FLOOR DECK.

F. Section 05500, METAL FABRICATIONS.

G. Section 07250, FIRESTOPPING.

H. Flashing wall and roof penetrations: Section 07600, FLASHING AND SHEET METAL.

I. Section 07920, SEALANTS AND CAULKING.

J. Section 09900, PAINTING.

K. Division 15, MECHANICAL

L. Division 16, ELECTRICAL

M. Other Sections where applicable.

1.3 QUALITY ASSURANCE

A. Qualify welding processes and operators for structural steel according to AWS D1.1 "Structural Welding Code--Steel."

B. Qualify welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions of ASME B31 Series "Code for Pressure Piping."

2. Certify that each welder has passed AWS qualification tests for the welding processes involved and that certification is current.

C. Products Criteria:

1. All equipment furnished as part of the work shall comply with the latest editions of all applicable state and municipal "energy codes." Provide certification from the equipment suppliers for all energy-consuming equipment that the equipment fully complies with these codes. Equipment submissions will not be accepted for review unless accompanied by such certification in writing.

2. All equipment and materials shall be new and without blemish or defect.

3. New equipment and materials shall be Underwriters Laboratories, Inc. (U.L.) labeled and/or listed where specifically called for, or where normally subject to such U.L. labeling and/or listing services.

4. All equipment and materials shall be free of asbestos.

5. Electrical equipment and materials shall be products which will meet with the acceptance of the agency inspecting the electrical work. Where such acceptance is contingent upon having the products examined, tested and certified by Underwriters or other recognized testing laboratory, the product shall be examined, tested and certified.. Where no specific indication as to the type or quality of materials or equipment is indicated, a first class standard article shall be furnished.

6. It is the intent of these specifications that wherever a specific manufacturer of a product is specified or scheduled, and the specifications include other approved manufacturers or the terms "other approved" or "or approved equal" or "equal" are used, the submitted item must conform in all respects

to the specified item. Consideration will not be given to claims that the submitted item meets the performance requirements with lesser construction (such as lesser heat exchange surface, smaller motor HP, etc.). Performance as delineated in schedules and in the specifications shall be interpreted as minimum performance. In many cases equipment is oversized to allow for pick-up loads which cannot be delineated under the minimum performance.

7. All equipment of one type (such as fans, pumps, coils, etc.), shall be the products of one Manufacturer.

8. Substituted equipment or optional equipment where permitted and approved, must conform to space requirements. Any substituted equipment that cannot meet space requirements, whether approved or not, shall be replaced at the Contractor's expense. Any modifications of related systems as a result of substitutions shall be made at the Contractor's expense.

9. 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 ability of the material or equipment involved or the mechanical performance of equipment. Approval of Shop Drawings does not invalidate the plans and specifications if in conflict, unless a letter requesting such change is submitted and approved on the Engineer's letterhead.

10. Substitutions of Mechanical Equipment for that shown on the schedules or designated by model number in the specifications will not be considered if the item is not a regular cataloged item shown in the current catalog of the manufacturer.

D. Manufacturer's Recommendations: Where installation procedures of any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end-caps. Maintain end-caps through shipping, storage, and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.

B. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. When stored inside, do not exceed structural capacity of the floor.

C. Protect flanges, fittings, and piping specialties from moisture and dirt.

D. Protect stored plastic pipes from direct sunlight. Support to prevent sagging and bending.

1.5 PROTECTION AND CLEANING

A. It shall be this trade's responsibility to store his materials in a manner that will maintain an orderly clean appearance. If stored on-site in open or unprotected areas, all equipment and material shall be kept off the ground by means of pallets or racks, and covered with tarpaulins.

B. The inlet and discharge openings of all fan coil, VAV Box, Fan Powered Box, and other terminal units shall be kept covered until all local plastering, parging, etc. is completed, and the units are ready to run.

C. Equipment and material if left in the open and damaged shall be repainted, or otherwise refurbished at the discretion of the owner. Equipment and material is subject to rejection and replacement if in the opinion of the engineer, or in the opinion of the manufacturer's engineering department, the equipment has deteriorated or been damaged to the extent that its immediate use is questionable, or that its normal life expectancy has been curtailed.

D. During the erection protect all ductwork, duct lining, insulation, piping, and equipment from damage and dirt. Cap the open top of all ductwork and piping installed vertically.

E. After completion of project, clean the exterior surface of all equipment included in this division of work including, but not limited to, concrete residue.

F. Chemical Cleaning: 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. The cleaning chemicals shall be added by the mechanical trade. The chemical supplier shall verify that the chemicals are compatible with all 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 flushing to insure all cleaning chemicals have been removed from each system. The mechanical trade shall block open all modulating valves, zone valves and all other system restrictions. If building pumps are not available, this trade shall provide portable pumps to circulate water for cleaning.

G. A certificate of cleaning shall be provided by the cleaning chemical supplier to the Architect's representative.

1.6 FIRE AND SMOKE DETECTION

A. Fire and smoke detection system will be provided and installed by the Electrical trade. The HVAC trade will provide suitable openings (as recommended by the Smoke Detection System Manufacturer) in sheet metal for sensing elements.

B. This Trade will provide access doors to make all such detection heads accessible.

C. This trade will provide bracing for smoke detection sampling tubes which exceed 48" in length.

1.7 SEQUENCING AND SCHEDULING

A. Coordinate mechanical equipment installation with other building components.

B. Arrange for chases, slots, and openings in building structure during progress of construction to allow for mechanical installations.

C. Coordinate the installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

D. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning prior to closing in the building.

E. Coordinate connection of electrical services.

F. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

G. Coordinate requirements for access panels and doors where mechanical items requiring access are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section "Access Doors."

H. Coordinate installation of identifying devices after completing covering and painting where devices are applied to surfaces. Install identifying devices prior to installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 CENTRAL CONTROL PANELS

A. Provide panel for alarm and start-stop functions.

B. Provide panel for alarm functions.

C. See drawings for details.

2.2 ACCESS DOORS IN FINISHED CONSTRUCTION

A. Access doors as required for operation and maintenance of concealed equipment, valves, controls, etc will be provided by another trade.

B. This Trade is responsible for access door location, size and its accessibility to the valves or equipment being served.

C. Coordinate and prepare a location, size, and function schedule of access doors required and deliver to a representative of the installing Trade. Furnish and install distinctively colored ___ buttons in finished ceiling.

D. Access doors shall be of ample size, minimum of 16" x 16".

E. Construct doors and frames to comply with the requirements of the NFPA and Underwriters Laboratories Inc. for fire rating. Install UL label on each door in a non-exposed location unless otherwise required by the local authority having jurisdiction.

2.3 DIELECTRIC FITTINGS

A. Provide dielectric fittings to isolate joined dissimilar materials to prevent galvanic action and stop corrosion. Fittings shall be of the non reducing type, which shall be suitable for the system fluid, pressure, and temperature and shall not restrict the flow.

B. For factory fabricated equipment, manufacturer shall submit method of compliance or exceptions (if applicable) in writing as part of the shop drawings submission for review and approval by Engineer.

C. It is the intent of this section that all system components (equipment connections, piping, etc.). Whether they are field installed or factory fabricated shall comply with paragraph A above.

D. See paragraph, PIPING SPECIALTIES, for additional details.

2.4 PIPE AND PIPE FITTINGS

A. Also refer to individual piping system specification Sections for pipe and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.5 JOINING MATERIALS

A. Refer to individual piping system specification Sections in Division 15 for special joining materials not listed below.

B. Pipe Flange Gasket Materials: Suitable for the chemical and thermal conditions of the piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3mm) maximum thickness, except where thickness or specific material is indicated.

2. ASME B16.20 for grooved, ring-joint, steel flanges.
3. AWWA C110, rubber, flat face, 1/8 inch (3 mm) thick, except where other thickness is indicated; and full-face or ring type, except where type is indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, except where other material is indicated.

D. Plastic Pipe Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, except where other type or material is indicated.

E. Solder Filler Metal: ASTM B 32.

F. Fittings for copper tubing shall be Chase Sweat Fittings, Mueller Brass Co.'s "Streamline" solder fittings, or "Arco" wrought-copper fittings. "T"-Drill type fittings are not acceptable. All piping shall be installed in a workmanlike manner, according to the manufacturer's instruction. All joints shall be thoroughly cleaned before connecting. All solder for copper tubing shall have a melting point of not less than 460 degrees F., composed of 95% tin and 5% antimony, or brazing filler metal melting at or above 1000°F (silver or copper-phosphorus) in accordance with the following table. Regardless of pressures in table below, use 95-5 tin antimony for fresh water.

SAFE STRENGTH OF SOLDERED JOINTS
Pressure Ratings
Maximum Service Pressure, PSI
Water

Solder used in Joints	Service Tempera-tures Deg. F.	1/4 to 1 inch Incl.	1-1/4 to 2 inches Incl.	2-1/2 to 4 inches Incl.	6 inches
95-5 Tin-Antimony	100	500	400	300	260
	150	400	350	275	260
	200	300	250	200	250
	250	200	175	150	250
Brazing Filler Metal* at or above 1000°F	250	300	210	170	150
	350	270	190	155	150

* For service temperatures 200° and below, the rated internal pressure is equal to that of tube being joined.

G. Brazing Filler Metals: AWS A5.8.
1. BCuP Series: Copper-phosphorus alloys.
2. BAg1: Silver alloy.

H. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

I. Solvent Cements: Manufacturer's standard solvents complying with the following:
1. Acrylonitrile-Butadiene-Styrene (ABS): ASTM D 2235.

2. Chlorinated Poly(Vinyl Chloride) (CPVC): ASTM F 493.
3. Poly(Vinyl Chloride) (PVC): ASTM D 2564.
4. PVC to ABS Transition: Made to requirements of ASTM D 3138, color other than orange.

J. Plastic Pipe Seals: ASTM F 477, elastomeric gasket.

K. Flanged, Ductile-Iron Pipe Gasket, Bolts, and Nuts: AWWA C110, rubber gasket, carbon steel bolts and nuts.

L. Couplings: Iron body sleeve assembly, fabricated to match outside diameters of plain-end pressure pipes.

1. Sleeve: ASTM A 126, Class B, gray iron.
2. Followers: ASTM A 47 (ASTM A 47M), Grade 32510 or ASTM A 536 ductile iron.
3. Gaskets: Rubber.
4. Bolts and Nuts: AWWA C111.
5. Finish: Enamel paint.

2.6 PIPING SPECIALTIES

A. Provide escutcheons on all exposed piping passing through walls, floors, partitions and ceilings, except provide close fitting metal escutcheons on both sides of piping (whether exposed or not) through required fire rated walls, floors, partitions & ceilings.

B. Escutcheons: Manufactured wall, ceiling, and floor plates; deep-pattern type where required to conceal protruding fittings and sleeves.
1. Inside Diameter: Closely fit around pipe, tube, and insulation.
2. Outside Diameter: Completely cover opening.
3. Cast Brass: One-piece, with set-screw.

C. Dielectric Fittings: Assembly or fitting, non-reducing type, having insulating material isolating joined dissimilar metals to prevent galvanic action and stop corrosion.
1. Description: Combination of copper alloy and ferrous; threaded, solder, plain, and weld neck end types and matching piping system materials.

2. Insulating Material: Suitable for system fluid, pressure, and temperature, does not restrict flow.

3. Dielectric Unions: Factory-fabricated, union assembly for 250-psig (1725kPa) minimum working pressure at a 180 deg F (82 deg C) temperature.

4. Dielectric Flanges: Factory-fabricated, companion-flange assembly for 150- or 300-psig (1035kPa or 2070kPa) minimum pressure to suit system pressures.

5. Dielectric-Flange Insulation Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

6. Dielectric Couplings: Galvanized-steel coupling, having inert and noncorrosive, thermoplastic lining, with threaded ends and 300-psig (2070kPa) minimum working pressure at 225 deg F (107 deg C) temperature.

7. Dielectric Nipples: Electroplated steel nipple, having inert and noncorrosive thermoplastic lining, with combination of plain, threaded, or grooved end types and 300-psig (2070kPa) working pressure at 225 deg F (107 deg C) temperature.

D. Mechanical Sleeve Seals: Modular, watertight mechanical type. Components include interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve. Connecting bolts and pressure plates cause rubber sealing elements to expand when tightened.

E. Sleeves: The following materials are for all wall, floor, slab, and roof penetrations:

F. Sleeve Materials

Type Designation	Sleeve Material
1	#18 gauge, galvanized steel.
2	Standard weight galvanized steel pipe.
3	Standard weight galvanized steel pipe with a continuously welded water stop of 1/4" steel plate extending from outside of sleeve a minimum of 2" all around - similar to F & S Mfg. Corp. Fig. 204.
4	Cast iron pipe sleeve with center flange - similar to James B. Clow & Sons No. F-1430 and F-1435.
5	Standard weight galvanized steel pipe with flashing clamp device welded to pipe sleeve or watertight sleeves - similar to Zurn 195-10 with oakum caulking as required.

6. Metal deck and wall sleeves similar to Adjust-To-Crete Mfg. Co.

G. Sleeve Sizes

1. Floors and required fire rated partitions - ½" maximum clearance between outside of pipe (or insulation on insulated pipes) and inside of sleeve.

2. Partitions not fire rated - 1-1/2" maximum clearance between outside of pipe (or insulation on insulated pipes) and inside of sleeve.

H. Sleeve Lengths

Location	Sleeve Length
Floors	Equal to depth of floor construction including finish. In waterproof floor construction sleeves to extend minimum of 2" above finished floor level.
Roofs	Equal to depth of roof construction including insulation.
Walls & Partitions	Equal to depth of construction and terminated flush with surfaces.

I. Sleeve Caulking & Packing.

Type Designation	Caulking & Packing Requirements
A	Space between pipe and sleeve packed with oakum or hemp and caulked watertight.
B	Space between pipe or pipe covering and sleeve shall be caulked with an incombustible, permanently plastic, waterproof non-staining compound leaving a finished smooth appearance or pack with mineral wool or other equally approved fire resistive material to within ½" of both wall faces and provide caulking compound as per above.

2.7 IDENTIFYING DEVICES AND LABELS

A. General: Manufacturer's standard products of categories and types required for each application as referenced in other Division 15 Sections. Where more than one type is specified for listed application, selection is Installer's option, but provide single selection for each product category.

B. Equipment Nameplates: Metal nameplate with operational data engraved or stamped, permanently fastened to equipment.

1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data.

2. Location: An accessible and visible location.

C. Stencils: Standard stencils, prepared for required applications with letter sizes conforming to recommendations of ASME A13.1 for piping and similar applications, but not less than 1-1/4-inch (30mm) -high letters for ductwork and not less than 3/4-inch (19mm) -high letters for access door signs and similar operational instructions.

1. Material: Fiberboard.

2. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray-can form and grade.

3. Identification Paint: Standard identification enamel of colors indicated or, if not otherwise indicated for piping systems, comply with ASME A13.1 for colors.

D. Pressure-Sensitive Pipe Markers: Manufacturer's standard preprinted, permanent adhesive, color-coded, pressure-sensitive vinyl pipe markers, conforming to ASME A13.1.

E. Plastic Duct Markers: Manufacturer's standard laminated plastic, color coded duct markers. Conform to following color code:

1. Green: Cold air.
2. Yellow: Hot air.
3. Yellow/Green: Supply air.
4. Blue: Exhaust, outside, return, and mixed air.
5. For hazardous exhausts, use colors and designs recommended by ASME A13.1.
6. Nomenclature: Include following:

F. Engraved Plastic-Laminate Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white (letter color) melamine subcore, except when other colors are indicated.

1. Fabricate in sizes required for message.
2. Engraved with engraver's standard letter style, of sizes and with wording to match equipment identification.
3. Punch for mechanical fastening.
4. Thickness: 1/8 inch (3 mm), except as otherwise indicated.
5. Fasteners: Self-tapping stainless-steel screws or contact-type permanent adhesive.

G. Plastic Equipment Markers: Laminated-plastic, color-coded equipment markers. Conform to following color code:

1. Green: Cooling equipment and components.
2. Yellow: Heating equipment and components.
3. Yellow/Green: Combination cooling and heating equipment and components.
4. Brown: Energy reclamation equipment and components.
5. Blue: Equipment and components that do not meet any of the above criteria.
6. For hazardous equipment, use colors and designs recommended by ASME A13.1.
7. Nomenclature: Include following, matching terminology on schedules as closely as possible:
8. Size: Approximately 2-1/2 by 4 inches (65 by 100 mm) for control devices, dampers, and valves; and 4-1/2 by 6 inches (115 by 150 mm) for equipment.

H. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in mechanical identification, with corresponding designations indicated. Use numbers, lettering, and wording indicated for proper identification and operation/maintenance of mechanical systems and equipment.
1. Multiple Systems: Where multiple systems of same generic name are indicated, provide identification that indicates individual system number as well as service such as "Boiler No. 3," "Air Supply No. 1H," or "Standpipe F12."

2.8 GROUT

A. Nonshrink, Nonmetallic Grout: ASTM C 1107, Grade B.
1. Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement grout, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi (34.50MPa), 28-day compressive strength.
3. Packaging: Premixed and factory-packaged.

2.9 DRIVE GUARDS

A. For all machinery and equipment provide guards for belts, chains, couplings, pulleys, sheaves, shafts, gears and other moving parts regardless of height above the floor.

B. Materials: Sheet steel, cast iron, expanded metal or heavy gauge wire mesh rigidly secured so as to be removable without disassembling pipe, duct, or electrical connections to equipment.

C. Access for Speed Measurement: One inch diameter hole at each shaft center.

2.10 ELECTRICAL MOTORS, MOTOR CONTROLS, AND WIRING

A. For all work required in conjunction with electrical motors, motor controls, and wiring, see complete delineation on the drawings under the title of "List of Electric Motors and Motor Controls" and the notes pertaining to same. Note that all motors, starters & motor control centers are purchased by the HVAC Trade. Motors for equipment shall be provided by the Equipment Manufacturer. All equipment shall have U.L. label where obtainable.

B. See “Automatic Controls” for separation of work for control wiring between Electrical and HVAC trades.

2.11 FIRE-STOPPING

A. Refer to Section, FIRESTOPPING.

B. HVAC trade is responsible for firestopping of HVAC work.

C. Firestopping system must be U.L. approved.

D. All spaces between ducts or pipes and their respective sleeves shall be packed full depth with mineral wool, or other equally approved fire resistant material, and compressed firmly in place. Fiberglass shall not be used. Sleeve clearances shall not exceed ½ inch between pipes (or ducts) and sleeves. Use individual sleeves for each pipe or duct. Use escutcheons on both sides of sleeves. This includes spaces between ducts on pipes and their respective sleeves or openings at fan rooms (whether walls are fire rated or not).

2.12 TOOLS AND LUBRICANTS

A. Furnish special tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.

B. Lubricants: A minimum of one quart of oil, and one pound of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

2.13 DAMPERS - GENERAL

A. All electric and/or pneumatic operated dampers which have a fire and/or smoke rating shall be furnished by the mechanical contractor. All other electric and/or pneumatic operated dampers shall be furnished by the Controls (ATC/BMS) Contractor. Fusible link dampers for fire protection, manual dampers for balancing and/or shut-off as well as dampers which are specified as part of factory built air handling units or terminal units shall be furnished by the mechanical contractor. All dampers shall be installed by the mechanical contractor.

B. Type “B” or “C” mountings shall be used for all dampers. Type “A” mountings are not permitted. All dampers are to be selected and installed so that the frames, stops, etc. are located outside of the airstream so as to provide a nominal 100% free area damper.

C. The mechanical contractor shall furnish damper actuators for all dampers that he furnishes. Where practical, actuators shall be factory mounted by the damper manufacturer. The actuators shall be located outside of the airstream. The mechanical contractor shall provide a terminal strip alongside the damper for all dampers he furnishes.

D. The controls contractor shall furnish damper actuators for all dampers that he furnishes. Where practical, actuators shall be factory mounted by the damper manufacturer. The actuators shall be located outside of the airstream. The controls contractor shall provide a terminal strip along side the damper for all dampers he furnishes.

E. Wiring for motor operated dampers that have a fire and/or smoke rating shall be provided by the mechanical trade from the damper actuator and any associated end switches and sensors to a terminal strip that is wall mounted along side the damper.

F. The controls contractor shall provide wiring as follows:

1. Between the central control system **[BMS]** and the terminal strip for all dampers monitored and/or controlled by the **[BMS][ATC]** whether or not the controls contractor has furnished the damper.

2. Between the terminal strip for all dampers and their associated thermostats, pressure switches, etc. whether or not the control contractor has furnished the damper.

G. Dampers incorporating multiple sections shall be controlled in unison. Where more than one (1) actuator serves a damper, then the actuators shall be driven in unison and the control wiring shall be provided accordingly.

H. Dampers incorporating multiple sections shall be designed in such a way that the actuators are easily accessible. Under no circumstances shall it be necessary to remove damper sections or structural or other fixtures to facilitate removal of damper motors. Provide access doors wherever necessary to meet this requirement.

I. The following table summarizes the trade responsibilities with respect to automatic dampers:

Description	*Non-Fire or Smoke Rated Dampers*	*Fire and/or Smoke Rated Dampers not Controlled by Fire Alarm System*	*Fire and/or Smoke Rated Dampers Controlled by Fire Alarm System*
Furnish Damper	Controls Contractor	Mechanical Trade	Mechanical Trade
Install Damper	Mechanical Trade	Mechanical Trade	Mechanical Trade
Furnish Actuator(s)	Controls Contractor	Mechanical Trade	Mechanical Trade
Install Actuator(s)	Mechanical Trade	Mechanical Trade	Mechanical Trade
Install and furnish terminal strip complete with all relays, wiring, etc.	Controls Contractor	Mechanical Trade	Mechanical Trade
Provide wiring between actuator, end switches, heat sensors, and terminal strip	Controls Contractor	Mechanical Trade	Mechanical Trade
Provide wiring from central control system (BMS) to damper terminal strip.	Controls Contractor	Controls Contractor	Controls Contractor
Provide wiring from FAS to damper terminal strip.	Controls Contractor	Controls Contractor	Electrical Trade
Furnish 120V main power to electrical actuators (see notes below)	Controls Contractor	Controls Contractor	Electrical Trade
Provide wiring from damper terminal strip to terminal strips for interlocked motors, etc.	Controls Contractor	Controls Contractor	Controls Contractor
Provide wiring from damper terminal strip directly to thermostats, etc.	Controls Contractor	Controls Contractor	Controls Contractor

<u>NOTES</u>

1. Controls contractor shall have overall responsibility for the complete coordination of the work and the operation of the damper/actuator installation.

2. In mechanical rooms 120V power circuits will be provided from an emergency distribution board. These circuits will be terminated in a junction box located in each associated mechanical room and shall be used by the controls contractor to supply local control panels and critical equipment.

   These circuits will also be used by the electrical trade to supply dampers, etc. , requiring control by the Fire Alarm System. Final connection from the terminal strips to the actuators, end switches and sensors shall be by the mechanical trade.

3. For dampers not requiring control by the fire alarm system and for other non-critical equipment, obtain power from either the emergency circuits as detailed above or from the motor starter terminal trip. All wiring shall be by the controls contractor.

2.14 DAMPER TERMINAL STRIPS

A. Terminal strip(s) shall be provided along side all motorized dampers. If the damper has a smoke and/or fire rating, the terminal strip shall be provided by the Mechanical Trade. If the damper does not have a fire and/or smoke rating then the terminal strip shall be provided by the controls contractor.

B. Where dampers are furnished by the controls contractor then he shall provide relays, interconnect wiring and other components to meet the requirements detailed below. The terminal strip(s), relays, etc. shall be housed in wall mounted enclosures which meet the specifications detailed for local starter enclosures.

C. The terminal strip shall be wired such that the Central Control System (ATC/BMS) can undertake the following control and monitoring functions:

   1. Open Control - A pair of terminals shall be wired such that when a controls (ATC/BMS) relay closes a contact pair across these terminals the damper is driven open. If the damper is two position with an actuator which drives closed and springs open on loss of power then these terminals shall not be used. This signal from the Central Control System (ATC/BMS) shall be overridden by a close signal from the Fire Alarm System (FAS) Where dampers are interlocked to motors then the wiring shall be to these terminals.

   2. Close Control - A pair of terminals shall be wired such that when a controls (ATC/BMS) relay closes a contact pair across these terminals the damper is driven closed. If the damper is two position with an actuator which drives open and springs closed on loss of power then these terminals shall not be used. This signal from the Central Control System (ATC/BMS) shall be overridden by an open signal from the FAS.

3. Motor Interlock - A pair of terminals shall be wired to an end switch on the actuator such that the contacts between the terminals shall be closed when the damper is fully open and open when the damper is not fully open. This pair of terminals shall be used for interlocking a damper with a motor such that the motor will not be able to start if the damper is not fully open.

D. Purge Dampers

For each damper which is to be monitored and/or controlled by the Fire Alarm System (FAS), the damper actuator, heat sensor and end switches shall each be wired by the mechanical trade to a terminal strip(s) mounted adjacent to the damper so that the FAS can undertake the following control and monitoring functions:

1. FAS "Open/Close" Control - The damper will be driven open in response to closure of an FAS relay contact and will spring closed in response to opening of this relay contact.

2. FAS "Override Open" Control (Smoke Purge Dampers Only) - The damper will be re-opened, subsequent to a heat sensor initiated closure, in response to closure of a second FAS relay contact (or reclosure of the first contact for single sensor dampers).

3. FAS "Open/Closed" Status Monitoring Control (Smoke Purge Dampers Only) - End Switch closures will cause activation of FAS "opened" and "closed" relays in response to operation of end switches at both ends of travel.

4. FAS "Override of ATC (BMS)" Control - For each damper requiring both FAS and ATC (BMS) control, the Controls Contractor shall mount an interface relay within 30 circuiting feet of the damper terminal strip, so wired as to permit FAS override of the ATC (BMS) control.

E. The controls contractor's damper manufacturer shall provide all necessary wiring diagrams to the FAS contractors.

F. Dampers furnished by the mechanical trade shall have similar terminal strips to which the controls contractor shall wire where necessary.

G. Comply with code requirements. Segregate high and low voltage wiring & circuits and segregate the FAS and controls (ATC/BMS) terminals.

2.15 AUTOMATIC CONTROL VALVES - GENERAL

A. All automatic control valves controlled by the central control system (ATC/BMS) shall be furnished by the controls contractor unless noted otherwise in these documents.

B. All automatic control valves shall be installed by the mechanical trade.

C. The controls contractor shall provide wiring as follows:

1. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.

2. All wiring between the central control system (ATC/BMS) and the valve actuator shall be wired by the controls contractor.

3. All wiring between the valve actuator and their associated thermostats, pressure switches, control devices, etc. shall be wired by the controls contractor.

D. All wiring shall comply with code requirements. Segregate high and low voltage wiring & circuits and segregate the FAS and controls (ATC/BMS) terminals.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS--COMMON REQUIREMENTS

A. General: Install piping as described herein, except where system Sections specify otherwise. Individual piping system specification Sections in Division 15 specify piping installation requirements unique to the piping system.

B. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated, except where deviations to layout are approved on coordination drawings.

C. Coordinate location of piping, sleeves, inserts, hangers, ductwork and equipment. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Follow manufacturer's published recommendations for installation methods not otherwise specified.

D. Install gages, thermometers, valves and other devices with due regard for ease in reading or operating and maintaining said devices. Locate and position thermometers and gages to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.

E. Furnish and install all necessary float devices, aquastats, thermostats, pressure sensors, etc. required for alarm indication as indicated on the HVAC Motor Controls

Specifications sheet.

F. Install piping at required slope.

G. Install components having pressure rating equal to or greater than system operating pressure.

H. Install piping in concealed interior and exterior locations, except in equipment rooms and service areas.

I. Install piping free of sags and bends.

J. Install exposed interior and exterior piping at right angles or parallel to building walls. Diagonal runs are prohibited, except where indicated.

K. Install piping tight to slabs, beams, joists, columns, walls, and other building elements. Allow sufficient space above removable ceiling panels to allow for ceiling panel removal.

L. Install piping to allow application of insulation plus 1-inch (25mm) clearance around insulation.

M. Locate groups of pipes parallel to each other, spaced to permit valve servicing.

N. Install fittings for changes in direction and branch connections.

O. Install couplings according to manufacturer's printed instructions.

P. Install pipe escutcheons for pipe penetrations of concrete and masonry walls, wall board partitions, and suspended ceilings according to the following:

1. Chrome-Plated Piping: Cast-brass, one-piece, with set-screw, and polished chrome-plated finish. Use split-casting escutcheons, where required, for existing piping.

2. Uninsulated Piping Wall Escutcheons: Cast-brass or stamped-steel, with set-screw.

3. Uninsulated Piping Floor Plates in Utility Areas: Cast-iron floor plates.

4. Insulated Piping: Cast-brass or stamped-steel, with concealed hinge, spring clips, and chrome-plated finish.

5. Piping in Utility Areas: Cast-brass or stamped-steel, with set-screw or spring clips.

Q. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, concrete floor and roof slabs, and where indicated.

1. Cut sleeves to length for mounting flush with both surfaces.

2. Build sleeves into new walls and slabs as work progresses.

R. Sleeve Application

Sleeve Type Thru Required Fire Rated Construction	Sleeve Type Thru Non-Fire Rated Construction	Location	Sleeve Caulking & Packing Type Designation
5	5	Membrane waterproof floor, roof and wall construction	B Note: Another trade will carry membrane up around sleeve and down inside sleeve
5	5	Non membrane waterproof floor, roof and wall construction where flashing is required	A or B
2	1,2	Interior walls, partitions and floors	B
3 or 4	3 or 4	Exterior walls	A
2	6	Metal deck floors	B
1	1	Precast concrete floor with poured concrete topping. Note: Sleeves to have flat flanges and/or guides which rest on top of precast slab	B

S. Fire Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestopping sealant material. Firestopping materials are specified in Division 7 Section "Firestopping."

T. Verify final equipment locations for roughing in.

U. Refer to equipment specifications in other Sections for roughing-in requirements.

V. Piping Joint Construction: Join pipe and fittings as follows and as specifically required in individual piping system Sections.

1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Soldered Joints: Construct joints according to AWS "Soldering Manual," Chapter 22 "The Soldering of Pipe and Tube."

4. Brazed Joints: Construct joints according to AWS "Brazing Manual" in the "Pipe and Tube" chapter.

5. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full inside diameter. Join pipe fittings and valves as follows:

6. Welded Joints: Construct joints according to AWS D10.12 "Recommended Practices and Procedures for Welding Low Carbon Steel Pipe" using qualified processes and welding operators according to the "Quality Assurance" Article.

7. Flanged Joints: Align flange surfaces parallel. Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.

8. Plastic Pipe and Fitting Solvent-Cement Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join pipe and fittings according to the following standards:

9. Plastic Pipe and Fitting Heat-Fusion Joints: Prepare pipe and fittings and join with heat-fusion equipment according to manufacturer's printed instructions.

W. Piping Connections: Except as otherwise indicated, make piping connections as specified below.

1. Install unions in piping 2 inches (50 mm) and smaller adjacent to each valve and at final connection to each piece of equipment having a 2-inch (50mm) or smaller threaded pipe connection.

2. Install flanges in piping 2-1/2 inches (65 mm) and larger adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.

3. Wet Piping Systems (Water and Steam): Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

X. All welding elbows shall be long radius elbows as manufactured by Tube Turn, ANSI B16.9.

Y. Where welding is used, fittings shall be Tube Turn, Bonney Forge, Taylor Forge, Ladish, or other approved manufacture, ANSI B-16.9. Welding end fittings shall have the same bursting pressure as pipe of the same size and schedule. Tee fittings shall be one piece except that weldolets are permitted where branches are at least one pipe size less than the main.

Z. All cast iron fittings shall be Stockham, Grinnell, or other approved.

3.2 PRESSURE TESTING - ALL PIPING SYSTEMS

A. Water shall not be introduced into piping systems for testing without water treatment. All piping systems shall be tested to a hydrostatic pressure at least 1-1/2 times the maximum operating pressure (but not less than 40 lbs. per sq. in.) for a sufficiently long time, but not less than 4 hours, to detect all leaks and defects. Where necessary, piping shall be tested in sections to permit the progress of the job.

B. Hydrostatic Testing Corrosion Inhibitor

1. If sections of system must be hydrostatically tested prior to cleanout, appropriate inhibitor shall be added to the test water at sufficient level to totally passivate metal and provide protective film on pipe surfaces to prevent corrosion prior to cleanout and treatment.

2. Mechanical Contractor shall be responsible to coordinate this treatment with the water treatment contractor. At no time shall the Mechanical Contractor add water to a system without treatment.

3.3 EQUIPMENT INSTALLATION--COMMON REQUIREMENTS

A. Install equipment to provide the maximum possible headroom where mounting heights are not indicated.

B. Install equipment according to approved submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to the Architect.

C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, except where otherwise indicated.

D. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

E. Install equipment giving right-of-way to piping systems installed at a required slope.

3.4 LABELING AND IDENTIFYING

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.

1. Stenciled Markers: Complying with ASME A13.1.

2. Plastic markers, with application systems. Install on pipe insulation segment where required for hot noninsulated pipes.

3. On exposed piping apply bands on 30 foot centers of straight runs, at valve locations, at points where piping enters and leaves a partition, wall, floor or ceiling.

4. On concealed piping installed above removable ceiling construction apply bands in manner described for exposed piping.

5. On concealed piping installed above non-removable ceiling construction, or in pipe shafts, apply bands at valve or other devices that are made accessible by means of access doors or panels.

6. Apply bands at exit and entrance points to each vessel, tank or piece of equipment.

7. Band widths shall be 8" for pipes up to 10 inch diameter and 16" wide for larger diameter piping. Letter heights stating service shall be preprinted on band 3/4" high for 8 inch bands and 1-1/2" high for 16 inch bands.

8. For insulated pipes apply bands after insulation and painting work has been completed.

9. Colors shall conform to ASME Standard A13.1. Provide 24 additional bands of each type for future use by Owner's personnel.

10. Follow manufacturer's instructions for application procedures using non-combustible materials and contact adhesives.

B. Equipment: Install engraved plastic laminate sign or equipment marker on or near each major item of mechanical equipment.

1. Lettering Size: Minimum 1/4-inch (6mm) -high lettering for name of unit where viewing distance is less than 2 feet (0.6 m), ½-inch (13mm) -high for distances up to 6 feet (1.8 m), and proportionately larger lettering for greater distances. Provide secondary lettering 2/3 to 3/4 of size of principal lettering.

2. Text of Signs: Provide text to distinguish between multiple units, inform

operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to name of identified unit.

C. Duct Systems: Identify air supply, return, exhaust, intake, and relief ducts with duct markers; or provide stenciled signs and arrows, showing duct system service and direction of flow.

1. Location: In each space where ducts are exposed or concealed by removable ceiling system, locate signs near points where ducts enter into space and at maximum intervals of 50 feet (15 m).

D. Adjusting: Relocate identifying devices which become visually blocked by work of this Division or other Divisions.

E. Valves

1. Attach a 2" round brass tag stamped with designating numbers 1" high filled in with black enamel to each valve, except those on fixtures.

2. Securely fasten valve tag to valve spindle or handle with a brass chain.
3. Provide approved ceiling tile markers in areas where removable ceilings occur to indicate location of valves or other devices.

F. Motor Control Identification

1. Mount black lamacoid nameplates on each motor controller identifying primary control function and individual position indication such as Pump No. 1, etc. Nameplates shall be cut through to white background and have beveled edges. Mount with chromium plated acorn head screws.

G. Schedules and Charts

1. Furnish to Owner's Representative three (3) complete framed plastic laminated valve tag schedules. Schedule shall indicate tag number, valve location by floor and nearest column number, valve size and service controlled.

3.5 PAINTING AND FINISHING

A. Refer to Division 9 Section "Painting" for field painting requirements.

B. Damage and Touch Up: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 PANS AND DRAINS OVER ELECTRICAL EQUIPMENT:

A. This contractor shall examine the drawings and in cooperation with the Electrical Trade confirm the final location of all electrical equipment to be installed in the vicinity of piping. Plan and arrange all overhead piping no closer than four feet from a vertical line above electrical equipment, including but not limited to, elevator machine room equipment, main switchgear equipment, motor control centers, starter, electric motors, switchboards, panelboards, or similar equipment. Piping is not permitted in Electric Equipment, Transformer, Switch Gear, Elevator Equipment, Telephone Gear Rooms.

B. Where the installation of piping does not comply with the requirements of the foregoing paragraph, where feasible the piping shall be relocated.

C. Furnish gutters as follows:

1. Provide and erect a gutter of 16 ounce cold rolled copper or 18 gauge galvanized steel, under every pipe which is within 4'-0" from a vertical line to any motor, electrical controllers, switchboards, panelboards, or the like.

2. Each gutter shall be reinforced, rimmed, soldered and made watertight, properly suspended and carefully pitched to a convenient point for draining. Provide a 3/4" drain, with valve as directed, to nearest floor drain or slop sink, as approved.

3. In lieu of such separate gutters, a continuous protecting drain pan of similar construction adequately supported and braced, properly rimmed, pitched and drained to a floor drain or suitable waste, may be provided over any such electrical equipment, and extending 3'-0" in all directions beyond the electrical equipment, over which such piping has to run.

3.7 CONCRETE BASES

A. Construct concrete equipment bases of dimensions indicated, but not less than 4 inches (100 mm) larger than supported unit in both directions. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Refer to concrete strength and reinforcement as specified in Division 3 Section "Cast-in-Place Concrete."

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGE

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

B. Field Welding: Comply with AWS D1.1 "Structural Welding Code--Steel."

3.9 GROUTING

A. Install nonmetallic nonshrink grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix grout according to manufacturer's printed instructions.

B. Clean surfaces that will come into contact with grout.

C. Provide forms for placement of grout, as required.

D. Avoid air entrapment when placing grout.

E. Place grout to completely fill equipment bases.

F. Place grout on concrete bases to provide a smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout according to manufacturer's printed instructions.

3.10 WELDING PROCEDURE

A. Pipe welding shall comply with the provisions of the latest revision of ANSI/ASME B31.9 Building Services Piping, or such state or local requirements as may supersede codes mentioned above.

B. Pipe welding for MPS/HPS (15 psig and above) shall be in accordance with ASME B31.1 Power Piping Code, or such state or local requirements as may supersede codes mentioned above.

C. Before any new pipe welding is performed, submit a copy of welding Procedure Specifications together with proof of its qualification as outlined and required by the most recent issue of the code having jurisdiction.

D. Before any operator shall perform any pipe welding, submit the operator's Qualification Record in conformance with provisions of the code having jurisdiction, showing that the operator was tested under the proven Procedure Specification submitted.

E. Repair or replace any work not in accordance with these specifications.

3.11 EXCAVATION AND BACKFILL

A. All excavation and backfill for HVAC work will be done by the HVAC Trade.

B. The work includes removal of surface improvements, excavating including hand excavation, sheeting, shoring, bracing, maintaining and protecting existing structures, utilities, pavements, shrubbery; dewatering by pumping of all water from excavation, bedding, backfilling, and compacting, restoration of surface improvements and cleaning up of the site.

C. Instructions:

1. Trenches shall be excavated so that pipe can be laid to the alignment and depth indicated on the drawings, and shall be excavated only so far in advance of pipe laying as approved.

2. Width of trenches shall be held to a minimum consistent with the type of material encountered and the size of piping being laid, but the width at the top of the pipe shall not be more than 2 feet plus outside diameter of pipe. Excavation for manholes and other accessories shall have 12 inch minimum and a 24 inch maximum clearance on all sides.

3. Before fill or backfilling commences, all trash, debris, and other foreign material shall be removed from trenches to be backfilled by this Trade. Fill material shall be free from timber, rocks 3" or larger, organic material, frozen material, and other unsuitable material as determined by the Architect. Filling shall not be done in freezing weather, unless specifically approved. No filling shall be done when material already in place is frozen.

4. In filling around pipe, deposit backfill material in successive horizontal layers not exceeding 6" in thickness before compaction. Compact each layer thoroughly by means of approved mechanical tampers. Tech special care to obtain compaction under pipe haunches. Deposit backfill adjacent to pipes on both sides to approximately same elevation at the same time. Continue this method of filling and compacting until backfill is at least 18" above top of pipe.

5. Backfilling for the remainder of pipe trenches to subgrades of paved or landscaped areas shall be done by mechanical tamping and rolling equipment, except that the use of such equipment is prohibited when said use may result in damage to pipelines or structures.

6. All copper tubing laid in ground shall be backfilled around and one (1) foot over with good clean earth, free from stone or cinders, carefully tamped under and around the tubing for its full length. The remainder of the backfill shall be free from stones larger than (3) inches in diameter and shall be satisfactorily compacted by puddling and tamping.

7. Backfill shall be moistened as necessary for proper compaction. Water settling of fill will not be permitted.

8. Complete backfilling of pipe trenches as soon as possible after the pipe is laid and tested.

9. Existing pavements, roadways, walkways, curbs and landscaped areas disturbed during the progress of the excavation and backfill work shall be restored to their original condition at no additional cost to the Owner.

10. Backfill shall be compacted to a minimum of 90% of modified AASHO maximum density as defined by ASTM D-1557. Any layer of fill, or portion thereof, which is not compacted to the required density shall be

recompacted until the specified density is achieved, or the layer shall be removed.

END OF SECTION 15050

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. This section is a part of all plumbing sections.

1.2 SUMMARY

A. Work Included:

1. The system shall include but not limited to the following: All plumbing fixtures and accessories, piping, fittings, valves, strainers, pumps, water distribution, gas distribution, water heaters, storm, sanitary, vents, interceptors, gages, thermometers, equipment and piping identification.

B. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.

2. Transition fittings.

3. Dielectric fittings.

4. Mechanical sleeve seals.

5. Sleeves.

6. Escutcheons.

7. Grout.

8. Mechanical demolition.

9. Equipment installation requirements common to equipment sections.

10. Painting and finishing.

11. Concrete bases.

12. Supports and anchorages.

C. Related Work include the following:

1. Division 2, Section 02200, EARTHWORK.
2. Division 3, Section 03300, CAST-IN PLACE CONCRETE.
3. Division 5, Section 05500, METAL FABRICATIONS.
4. Division 7, Section 07841, FIRESTOPPING.
5. Division 7, Section 07920, SEALANTS AND CAULKING.
6. Division 9, Section 09900, PAINTING.
7. Division 16, ELECTRICAL.
8. Other Sections where applicable.

1.3 CODES, PERMITS AND INSPECTIONS

A. All work shall meet or exceed the latest requirements of all national, state, county, municipal and other authorities exercising jurisdiction over construction work at the project.

B. All required permits, approval and inspection certificates shall be obtained, paid for, and made available at the completion of the work, by the Plumbing Contractor.

C. Installation procedures, methods, and conditions shall comply with the latest requirements of The Federal Occupational Safety and Health Act (OSHA).

D. Prepare and submit to the building owner a set of “as-built” record drawings for approval, in a form acceptable to the building owner.

E. The Contractor shall be responsible for the installation and filing until the installation has been approved by the authorities having such jurisdiction.

F. Prepare and submit to the Engineer a set of “as-built” record drawings for approval, in a form acceptable to the Engineer.

1.4 GUARANTEES AND CERTIFICATIONS

A. All work shall be guaranteed to be free from leaks and defects. Any defective materials or workmanship, as well as damage to the work of all trades resulting from same, shall be replaced or repaired as directed for the duration of stipulated guaranteed periods.

B. The duration of guarantee periods following the date of beneficial use of the system shall be one year. Beneficial use is defined as operation of the system to obtain its intended use.

C. The date of acceptance shall be the date of the final payment for the work or the date of a formal notice of acceptance, whichever is earlier.

D. Non-durable replaceable items, such as water filter media, do not require replacement after the date of acceptance. If received in writing, requests to have earlier acceptance dates established for these items will be honored.

E. Certification shall be submitted attesting to the fact that specified performance criteria are met by all items of plumbing equipment.

1.5 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. Piping: Pipe, fittings, flanges, valves, controls, hangers, drains, insulation, and items customarily required in connection with the transfer of fluids.

G. By Other Trades: By persons or parties responsible for work at the project other than the party or parties who have been duly awarded the contract for the work of this Trade. In the event that this document is used to acquire work as part of a general construction contract the words “by other trades” shall mean by persons or parties who are not anticipated to be the sub-contractor for this trade working together with the general contractor. In this context the words “by other trades” shall not be interpreted to mean not included in the overall contract.

H. The following are industry abbreviations for plastic materials:

1. ABS: Acrylonitrile-butadiene-styrene plastic.

2. CPVC: Chlorinated polyvinyl chloride plastic.

3. PE: Polyethylene plastic.

4. PVC: Polyvinyl chloride plastic.

I. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.

2. NBR: Acrylonitrile-butadiene rubber.

1.6 SUBMITTALS

A. In accordance with Division 1, Section 01330, SUBMITTAL PROCEDURES, furnish the following:

B. Prior to purchasing any equipment or materials, a list of their manufacturers shall be submitted for approval.

C. Prior to assembling or installing the work, the following shall be submitted for approval:

1. Scale drawings indicating insert and sleeve locations if required by Architect or Structural Engineer.

2. Scale drawings showing all piping and duct runs with sizes, elevations and appropriate indication of coordination with other trades. This submission to us shall consist of one (1) original and (6) six prints.

3. Catalog/internet information, factory assembly drawings and field installation drawings as required for a complete explanation and description of all items of equipment.

D. Documents will not be accepted for review unless:

1. They are submitted as a package where they pertain to related items.

2. They are properly marked with service or function, project name, where they consist of catalog sheets displaying other items which are not applicable.

3. They indicate the project name and address along with the Contractor's name, address and phone number.

4. They are properly marked with external connection identification as related to the project where they consist of standard factory assembly or field installation drawings.

E. Shop Drawing Review

1. The purpose of the review of shop drawings is to maintain integrity of the design. Unless the contractor clearly points out changes, substitutions, deletions or any other differences between the submission and the Contract Documents in writing on the Contractor's letterhead, approval by the Engineer or Architect does not constitute acceptance. It is not to be assumed that the engineer has read the text nor reviewed the technical data of a manufactured item and its components except where the Vendor has pointed out differences between his product and the specified model.

2. It is the responsibility of the contractor to confirm all dimensions, quantities, and the coordination of materials and products supplied by him with other trades. Approval of shop drawings containing errors does not relieve the contractor from making corrections at his expense.

3. Substitutions of equipment, systems, materials, must be in accordance with the substitutions section of these specifications and coordinated by the Contractor with his own or other trades which may be involved with the item, such as, but not limited to, equipment substitutions which change electrical requirements, or hanging or support weights or dimensions.

4. Any extra charges or credits which may be generated by other trades due to substitutions will not be accepted unless the Contractor has an agreement in writing with the Owner.

5. Substitutions of equipment, systems, etc. requiring approval of local authorities must comply with such regulations and be filed at the expense of the Contractor (should filing be necessary). Substitutions are subject to approval or disapproval by the Engineer. The Contractor in offering substitutions shall hold the Owner and Engineer harmless if the substituted item is an infringement of patent held by the specified item.

6. Shop drawings shall show all data required by NFPA.

F. Explanation of Shop Drawing Stamp

1. Reviewed indicates that we have not found any reason why this item should not be acceptable within the intent of the documents.

2. Make Corrections Noted indicates that we have found questionable components which if corrected or otherwise explained make the product acceptable.

3. Revise and Resubmit indicates that this item should be resubmitted for approval before further processing.

   (a) If both "Reviewed As Noted" and "Revive and Resubmit" are checked, the resubmittal is for record purposes only.

4. No shop drawing stamp or note shall constitute an order to fabricate or ship. Such notification can only be performed by the Project Manager for Construction, the Contractor scheduling his own work, or the Owner.

G. Maintenance Data and Operating Instructions:

1. Maintenance and operating manuals in accordance with Division 1, Section 01400, QUALITY REQUIREMENTS, Paragraph, INSTRUCTIONS, for systems and equipment.

2. After all final tests and adjustments have been completed, fully instruct the proper Owner's Representative in all details of operation for equipment installed. Supply qualified personnel to operate equipment for sufficient length of time to assure that Owner's Representative is properly qualified to take over operation and maintenance procedures. Supply qualified personnel to operate equipment for sufficient length of time as required to meet all governing authorities in operation and performance tests.

3. Furnish required number of manuals, in bound form containing data covering capacities, maintenance of operation of all equipment and apparatus. Operating instruction shall cover all phases of control and include the following:

    (a) Performance Curves: For pumps, and similar equipment at the operating conditions.

    (b) Lubrication Schedule: Indicating type and frequency of lubrication required.

    (c) List of Spares: Recommended for normal service requirements.

    (d) Parts List: Identifying the various parts of the equipment for repair and replacement purposes.

    (e) Instruction Books may be standard booklets but shall be clearly marked to indicate applicable equipment.

    (f) Wiring Diagrams: Generalized diagrams are not acceptable, submittal shall be specifically prepared for this Project.

    (g) Automatic Controls: Diagrams and functional descriptions.

4. Where applicable, one set of operating and maintenance instructions shall be neatly framed behind glass and hung adjacent to the equipment concerned.

H. Product Data: For the following:

1. Transition fittings.

2. Dielectric fittings.

3. Mechanical sleeve seals.

4. Escutcheons.

I. Welding certificates.

1.7 DELIVERY, STORAGE, HANDLING AND PROTECTION

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

C. This trade shall be responsible for its work and equipment until it is tested, has received final inspection and been accepted. Carefully store materials and equipment which are not immediately installed after delivery to site. Close open ends of work with temporary covers or plugs during construction to prevent entry of obstructing material.

D. This trade shall protect work and material of other trades from damage that might be caused by its work or workmen and make good damage thus caused.

1.8 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

1.9 COORDINATION DRAWINGS:

A. Prepare coordination drawings in accordance with Division 1 Section "PROJECT COORDINATION," to a scale of 3/8"=1'-0" or larger; detailing major elements, components, and systems of plumbing equipment and materials in relationship with other systems, installations, and building components in spaces such as typical floor and mechanical rooms. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of piping, equipment, and materials. Include the following:

(a) Planned piping layout, including valve and specialty locations and valve stem movement.

(b) Clearances for servicing and maintaining equipment, including space for equipment disassembly required for periodic maintenance.

(c) Equipment connections and support details.

(d) Exterior wall and foundation penetrations.

(e) Fire-rated wall and floor penetrations.

(f) Sizes and location of required concrete pads and bases.

(g) Clearances as required by Electric Code.

2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.

3. Prepare reflected ceiling plans to coordinate and integrate sprinkler installations, air outlets and inlets, light fixtures, communication systems components and other ceiling-mounted items.

B. Plumbing Coordination Drawings

1. This trade shall add to Coordination Drawings prepared by the HVAC Contractor showing all of the plumbing work (equipment, piping, conduit, etc.) to be installed as part of the work of this section of the specifications.

2. This Trade after showing all of the plumbing work shall forward the reproducible Coordination Drawings to the Electrical Contractor.

3. The sequence of coordination drawings shall be HVAC-PLBG-FP-ELEC-CM.

4. The plumbing Contractor shall attend a series of meetings arranged by the General Contractor/Construction Manage to resolve any real or apparent interferences or conflicts with the work of the other Contractors.

5. The plumbing Contractor shall then make adjustments to his work on the Coordination Drawings to resolve any real or apparent interferences or conflicts.

6. After any real or apparent interferences and conflicts have been incorporated into the Coordination Drawings, the plumbing Contractor shall "sign-off" the final Coordination Drawings.

7. The plumbing Contractor shall not install any of his work prior to "sign-off" of final Coordination Drawings. If the plumbing work proceeds prior to sign-off of Coordination Drawings, any change to the plumbing work to correct the interferences and conflicts which result will be made by the Plumbing Contractor at no additional cost to the project.

8. Coordination Drawings are for the Contractor's and Architects use during construction and shall not be construed as replacing any shop "as-built", or Record Drawings required elsewhere in these Contract Documents.

9. Architect's review of Coordination Drawings shall not relieve Contractor from his overall responsibility for coordination of all work performed pursuant to the Contract or from any other requirements of the Contract.

C. Record Drawings

1. As part of the required plumbing work, a complete set of "as-built" or record drawings shall be made up and delivered to the architect.

2. The drawings shall show:-

   (a) All work installed exactly in accordance with the original design.

   (b) All installed as a modification or addition to the original design.

   (c) The dimensional information necessary to delineate the exact location of all piping runs which are so concealed as to be untraceable by inspection through the regular means of access established for inspection and maintenance.

3. Where shop drawings have been prepared and approved, the "as-built" drawings shall be cross referenced to the respective shop drawing.

4. As-built record drawings shall include the updating of all equipment schedule sheets.

5. The record drawings shall be of legible reproducible and durable type.

6. The Contractor shall make arrangements with the Engineer to obtain design drawings on compact diskettes in AutoCad format for use as a basis for the "as-built" drawings. These documents remain the property of Cosentini Associates, Inc. and shall be used for no other purpose without expressed, written consent. The contractor shall assume all liabilities resulting from unauthorized use or modifications to the drawings.

7. Prior to developing any "as-built" drawings, the contractor shall coordinate with the Owner and the Architect Engineer the drawing layers, colors, etc., of the CAD drawings.

8. "As-built" information shall be submitted as follows:

   (a) Drawing files on compact disketts in AutoCad format.

   (b) One (1) set of reproducible drawings.

   (c) Two (2) sets of plots.

9. The quantity of design drawings which are made available shall in no way be interpreted as setting a limit to the number of drawings necessary to show the required "as-built" information.

10. Progress prints of record drawings shall be submitted monthly during the construction period for Architect's approval.

11. This trade shall submit the "as-built" set for approval by the Engineer in a form acceptable to the Engineer.

12. Final acceptance of the fire protection systems by the authority having jurisdiction will not be implemented until "as-built" drawings are on site.

1.10 INTERPRETATION OF THE DRAWINGS AND SPECIFICATIONS

A. As used in the drawings and specifications, certain non technical words shall be understood to have specific meanings as follows:

1. "Furnish"----------Purchase and coordinate deliver to the project site complete with every necessary appurtenance and support.

2. "Install"----------Unload at the coordinated delivery point and time at the site and perform every operation necessary to establish secure mounting and correct operation at the proper location in the project.

3. “Provide"----------"Furnish" and "Install".

B. Except where modified by a specific notation to the contrary, it shall be understood that the indication and/or description of any item, in the drawings or specifications or both, carries with it the instruction to furnish and install the item, regardless of whether or not this instruction is explicitly stated as part of the indication or description.

C. It shall be understood that the specifications and drawings are complementary and are to be taken together for a complete interpretation of the work. Where there are conflicts between the drawings and specifications or within the specifications or drawings themselves, the items of higher standard shall govern.

D. No exclusions from, or limitations, in the language used in the drawings or specifications shall be interpreted as meaning that the appurtenances or accessories necessary to complete any required system or item of equipment are to be omitted.

E. The drawings of necessity utilize symbols and schematic diagrams to indicate various items of work. Neither of these have any dimensional significance nor do they delineate every item required for the intended installations. The work shall be installed, in accordance with the diagrammatic intent expressed on the drawings, and in conformity with the dimensions indicated on final architectural and structural working drawings and on equipment shop drawings.

F. No interpretation shall be made from the limitations of symbols and diagrams that any elements necessary for complete work are excluded.

G. Certain details appear on the drawings which are specific with regard to the dimensioning and positioning of the work. These details are intended only for the purpose of establishing general feasibility. They do not obviate field coordination for the indicated work.

H. Information as to the general construction shall be derived from structural and architectural drawings and specifications only.

I. The use of words in the singular shall not be considered as limiting where other indications denote that more than one item is referred to.

J. In the event that extra work is authorized, and performed by this trade, work shown on drawings depicting such work, and/or described by Bulletin is subject to the base building specifications in all respects.

1.11 SEPARATION OF WORK BETWEEN TRADES

A. The Specifications for the overall construction delineate various items of work under separate trade headings. The list below sets forth this delineation to the extent that it affects the Plumbing Work.

B. In the absence of more detailed information, this list shall be taken as a specific instruction to the Plumbing trade to include the work assigned to it.

C. Indications that the Plumbing trade is to perform an item of work mean that it is to perform the work for its own accommodation only, except as specifically noted otherwise.

D. Oth = Other than electrical or mechanical

Plb = Plumbing

FP = Fire Protection

Htg = Heating, Ventilating & Air Conditioning

Elec = Electrical

f = Furnished

I = Installed

p = Provided (furnished and installed)

Item	Oth	Plb	FP	Htg	Elec	Notes
Motor for plumbing equipment		p				
Motor controls for plumbing equipment.		f			I	Specifications and drawings delineate detailed exceptions.
Wiring for plumbing equipment motors and motor controls.					p	Specifications and drawings delineate detailed exceptions.
Temporary heat	p					
Temporary Water	p					
Temporary light and power.	P					
Temporary toilets.	P					
Natural gas piping and valves for gas fired equipment.		P				Final connections by the Plumbing contractor.
Hoisting	p					

Item	Oth	Plb	FP	Htg	Elec	Notes
Rigging	p					
Bracing of building for safe rigging.		p				
Cutting, chasing and patching	p					Cost where due to late installation, or improper coordination of work is the responsibility of the delinquent trade.
Framed slots and openings in walls decks and slabs.	P					
Sleeves through slabs, decks and walls.		P				
Sleeves through membraned and waterproofed slabs, decks and walls.		P				
Waterproof sealing of pipes passing through sleeves.		P				
Waterproof sealing of sleeves through membraned through membraned and water proofed slabs.		P				
Fireproof sealing of excess openings in slabs, decks and fire rated walls.		P				
Excavation and backfill inside buildings.	P					
Excavation and backfill outside buildings.	P					
Keeping site and excavations free from water during construction.	P					To accommodate the overall project.
Fastenings		p				
Supports		p				
Concrete encasement of underground runs.	P					
Subsoil drainage inside building (footing drains)	p					To accommodate overall project.
Venting for gas tranes on gas fired equipment.				p		Complete.
Subsoil drainage outside building (footing drains)	p					To accommodate overall project.
Sewer manholes (interior)		p				Furnishing of covers, associated frames ane other hardware included in the Plumbing Contractor.
Floor drain flashing		p				
Base flashing for roof drains and all piping penetrating roof.	P					

Item	Oth	Plb	FP	Htg	Elec	Notes
Cap flashing for all piping penetrating roof.		P				
Concrete foundations, pads and bases.	P					Furnishing of anchors and vibration mounts included in the Plumbing Contractor.
Concrete (masonry) pits.	P					Plumbing Contractor to furnish sizes and locations.
Pit frames, covers, pumps, and controls.	P					Special covers sewage ejector pumps, sump pump, pumps, controls, covers and frames furnished by the Plumbing Contractors.
Trenches in building foundation.	P					
Field touch up painting of damaged shop coats.		P				
Prime coating hangers and supports.		P				
Rustproofing field cut and assembled iron supporting frames and racks.		P				
Finished painting	p					
Finished wall and ceiling access doors, panels and supporting frames.	P					Supplying list locating all required access doors (none to be less than 16" x 16") Included in Plumbing Contractor.
Cat walks to mechanical equipment.	P					Supplying list of locations where required included in the Plumbing Contractor.
Ladders to equipment and valves.	P					Supplying list of locations where required to be installed by the Plumbing Contractor.
Domestic make-up water piping for heating and air conditioning systems.		P				Final connections included in heating trade.
Toilet Room accessories.	f					Install certain toilet room accessories as required by local trade union jurisdiction.
Window washing machines	p					Required water outlet provided by Plumbing Contractor.
Plumbing fixtures and accessories.		P				
Soap dispensers on plumbing fixtures.		P				
Food service equipment.	P					

Item	Oth	Plb	FP	Htg	Elec	Notes
Rubbish removal.		P				Where one trade finishes and another installs, the installing trade removes the shipping and packaging materials which accumulate.
Special tools for equipment maintenance.		P				
Laboratory casework and equipment.	p					Plumbing Contractor to provide roughing and final connections.
Balance recirculation system(s).		P				Plumbing Contractor to provide equipment and labor.
Garage drainage and venting system to include gasoline and oil interceptor and venting.		P				Pit(s) provided by General Contractor.
Domestic water service from street main, including valve and valve bo. To capped OS&Y valve connection and water meter inside building.		P				
Electric heating cables for pipe tracing.					p	Insulation over heat tracing by Plumber.

E. The Plumbing Contractor is required to supply all necessary supervision and coordination information to any other trades who are to supply work to accommodate the Plumbing installation.

F. Where the Plumbing Trade is required to install items which it does not purchase, it shall include for such items:

1. The co-ordination of their delivery.

2. Their unloading from delivery trucks driven in to any designated point on the property line at grade level.

3. Their safe handling and field storage up to the time of permanent placement in the project.

4. The correction of any damage, defacement or corrosion to which they may have been subjected.

5. Their field assembly and internal connection as may be necessary for their proper operation.

6. Their mounting in place including the purchase and installation of all dunnage supporting members and fastenings necessary to adapt them to architectural and structural conditions.

7. Their connection to building systems including the purchase and installation of all terminating fittings necessary to adapt and connect them to the building systems.

8. Items which are to be installed but not purchased as part of the work of the Plumbing Contractor shall be carefully examined by this trade upon delivery to the project. Claims that any of these items have been received in such condition that their installation will require procedures beyond the reasonable scope of work of the Plumbing Contractor will be considered only if presented in writing within one week of the date of delivery to the project of the items in question. The work of the Plumbing Contractor shall include all procedures, regardless of how extensive, necessary to put into satisfactory operation, all items for which no claims have been submitted as outlined above.

1.12 APPLICABLE PUBLICATIONS:

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

Reference	Definition
ASTM	American Society for Testing Materials
ASPE	American Society of Plumbing Engineers
NFPA	National Fire Protection Association
UL	Underwriters Laboratories, Inc.
NEMA	National Electrical Manufacturers Assn.
FM	Factory Mutual
USAS	United States of America Standards Institute
ANSI	American National Standards Institute
AWWA	American Water Works Association
F.S.	Federal Specifications, US Government
I.S.O.	Insurance Services Organization
C.S.	Commercial Standards issued by the United States Department of Commerce.
M.S.S.	Manufacturers Standardization Society of the Valve and Fittings Industry
A.G.A.	American Gas Association, Inc.
A.S.H.R.A.E.	American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.

P.D.I.	Plumbing and Drainage Institute
N.S.F.	National Sanitation Foundation
A.S.S.E.	American Society of Sanitary Engineering
I.A.P.M.O.	International Association of Plumbing and Mechanical Officials
C.I.S.P.I.	Cast Iron Soil Pipe Institute
A.A.S.H.O.	American Association of State Highway Officials

1.13 SEISMIC DESIGN

A. This project is located within Seismic Zone___ as mapped in the Building Code. Special provisions are required for the support and restraint of equipment, piping, etc., in the event of earthquake so as to comply with the State Building Code, with supplements.

B. It shall be understood that the requirements of this seismic section are complementary to requirements delineated elsewhere for the support and fastening of equipment, piping, etc. Nothing on the drawings or specifications shall be interpreted as a reason to waive the requirements of this seismic section.

C. Floor mounted equipment shall be provided with approved seismic control devices as required to prevent overturning or sliding. Seismic restraints shall be capable of keeping equipment captive under seismic loads.

D. Ceiling mounted equipment shall be provided with approved seismic control devices as required to maintain the equipment in a captive attitude under seismic loads.

E. The seismic restraint design and construction requirements for equipment and piping incorporated as part of Life Safety Systems shall be such that these systems will remain in place and be functional following a major earthquake, and that the design shall consider lateral drifts between stories as specified by code.

F. All life safety systems whether isolated or not shall be bolted to structure to allow for the required acceleration. Bolt points and diameter of inserts shall be submitted and verified as part of the contractor's submission for each piece of equipment and certified by a licensed structural engineer.

G. Seismically restrain all piping with center bracing or Type II restraining system in accordance with NFPA guidelines to comply with the Building Code.

H. Equipment and piping submittals shall include the following in addition with the requirements delineated elsewhere.

1. Drawings and calculations (certified by a professional engineer) as required to show the number and location of seismic restraints and specified details of restraints including anchor bolts for mountings and maximum load (static plus dynamic expected at each restraint or snubbing device including fastening devices for the seismic restraints which are capable of maintaining equipment in a captive position when subjected to external forces required for life safety equipment as defined by the State Building Code.

2. Drawings, as required to show the number and location of seismic restraints and specific details of restraints including anchor bolts for mountings an maximum load (static plus dynamic at each seismic restraint location).

I. Seismic restraints shall be provided by a company specializing in vibration isolation and seismic restraints with five years minimum experience.

J. All seismic restraints shall be capable of safely accepting external forces required for life safety equipment without failure and shall maintain equipment, piping, etc. in a captive position. Seismic restraints shall not short circuit isolation systems or transmit objectionable vibration or noise, and shall be provided on all equipment as scheduled ion drawings. Calculations by registered structural engineer shall be submitted to verify snubber capabilities for each piece of equipment.

K. For all piping, regardless of size or length of support, all connections to the building structure must be positively made. Connections which depend all or in part on friction for their supporting action are not acceptable.

L. Do not use branch lines to brace main lines.

M. 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.

N. Provide large enough pipe sleeves through walls or floors to allow for anticipated differential movements.

O. 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' on center.

1.14 SEISMIC CERTIFICATION

A. Provide details for seismic restraint and bracing of equipment and piping. Such details shall be of complete detailed shop drawings based on the contractor's installation techniques, equipment arrangement and the specific routing of the work. The submission of shop drawings shall include all necessary calculations and manufacturer's certifications as required to demonstrate the suitability of the proposed installation. Calculations shall be performed by an approved licensed structural engineer with experience in the field of equipment support and seismic design, who shall be retained by the contractor for this purpose.

B. The supplier of the seismic restraints, braces and other devices shall have had the experience in designing and manufacturing such equipment for not less than 5 years. Responsibility shall include determining the location and sizes of all restrains and braces as required by the contractor's layout and installation drawings, and furnishing of all such devices with installation instructions. The supplier shall provide any necessary field supervision to insure that the seismic control devices are properly installed.

C. Calculations to demonstrate the adequacy of the proposed seismic devices shall be performed by Seismic Designs, Inc. or other approved structural engineering firm under the supervision of a licensed professional engineer having at least 5 years experience in seismic design.

1.15 GUARANTEES AND CERTIFICATIONS

A. All work shall be guaranteed to be free from leaks or defects. Any defective materials or workmanship as well as damage to the work of all trades resulting from same shall be replaced or repaired as directed for the duration of stipulated guaranteed periods.

B. The duration of guarantee periods following the date of beneficial use of the system shall be one year. Beneficial use is defined as operation of the system to obtain its intended use.

C. The date of acceptance shall be the date of the final payment for the work or the date of a formal notice of acceptance, whichever is earlier.

D. Certification shall be submitted attesting to the fact that specified performance criteria are met by all items of Plumbing equipment.

1.16 EXAMINATION OF SITE AND CONTRACT DOCUMENTS

A. Before submitting prices or beginning work, throughly examine the site and the Contract Documents.

B. No claim for extra compensation will be recognized if difficulties are encountered which examination of site conditions and Contract Documents prior to executing the Contract would have revealed.

1.17 WORKMANSHIP

A. The entire work provide in this Specification shall be constructed and finished in every aspect in a workmanlike and substantial manner.

B. It is not intended that the Drawings shall show every pipe, fitting and appliance. Plumbing Contractor shall furnish and install all such parts as may be necessary to complete the systems in accordance with the best trade practice.

C. Keep other trades fully informed as to shape, size and position of all openings required for apparatus and give full information to the General Contractor and other trades in a timely manner so that all opening may be built in advance. Furnish and install all sleeves, supports and the like as specified or as required.

D. In case of failure on the part of the Plumbing Contractor to give proper and timely information as required above, he shall do his own cutting and patching or have same done by the General Contractor, but in any case, without extra expense to the Owner.

E. Obtain detailed information from the manufacturers of apparatus as to the proper method of installing and connecting same. Obtain all information from the General Contractor and other trades which may be necessary to facilitate work and completion of the whole project.

1.18 CONTINUITY OF SERVICES

A. Do not interrupt existing services without Owner's Representative approval.

B. Schedule interruptions in advance, according to Owner's Representative instructions. Submit, in writing, with request for interruption, methods proposed to minimize impact on Owner's operations. Interruptions shall also be coordinated with the local fire department.

C. Interruptions shall be scheduled at such times of day and work to minimize impact on Owner's operations.

1.19 QUALITY ASSURANCE:

A. Products Criteria

1. All equipment furnished as part of the work shall comply with the latest editions of all applicable state and municipal "energy codes." Provide certification from the equipment suppliers for all energy-consuming equipment that the equipment fully complies with these codes. Equipment submissions will not be accepted for review unless accompanied by such certification in writing.

2. All equipment and materials shall be new and without blemish or defect.

3. New equipment and materials shall be Underwriters Laboratories, Inc. (U.L.) labeled and/or listed where specifically called for or where normally subject to such U.L. labeling and/or listing services.

4. Asbestos

   (a) All equipment and materials shall be free of asbestos.

5. Electrical equipment and materials shall be products which will meet with the acceptance of the agency inspecting the electrical work. Where such acceptance is contingent upon having the products examined, tested and certified by Underwriters or other recognized testing laboratory, the product shall be examined, tested and certified. Where no specific indication as to the type or quality of materials or equipment is indicated, a first class standard article shall be furnished.

6. It is the intent of these specifications that wherever a manufacturer of a product is specified, and the terms "other approved" or "or approved equal" or "equal" are used, the substituted item must conform in all respects to the specified item. Consideration will not be given to claims that the substituted item meets the performance requirements with lesser construction (such as lesser heat exchange surface, etc.). Performance as delineated in schedules and in the specifications shall be interpreted as minimum performance. In many cases equipment is oversized to allow for pick-up loads which cannot be delineated under the minimum performance.

7. All equipment of one type such as drains, pumps, fixtures, etc. shall be the products of one Manufacturer.

8. Substituted equipment or optional equipment where permitted and approved, must conform to space requirements. Any substituted equipment that cannot meet space requirements, whether approved or not, shall be replaced at the Contractor's expense. Any modifications of related systems as a result of substitutions shall be made at the Contractor's expense.

9. 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 ability of the material or equipment involved or the mechanical performance of equipment. Approval of Shop Drawings does not invalidate the plans and specifications if in conflict, unless a letter requesting such change is submitted and approved on the Engineer's letterhead.

10. Substitutions of equipment for that shown on the schedules or designated by model number in the specifications will not be considered if the item is not a regular cataloged item shown in the current catalog of the manufacturer.

11. Prohibition of Lead

    (a) The presence and use of lead is strictly prohibited in potable water systems.

    (b) Potable water shall not be subject to contact with lead in any form.

    (c) The design and manufacture of all materials and equipment (piping, fittings, joints, connections, solders, fixtures, accessories, etc.) provided, shall not contain lead in any form.

    (d) Contractor shall be responsible for all costs involved in testing and certifying that potable water systems, materials and equipment are lead free.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 15 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 15 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

(a) Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

(b) Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:

1. CPVC Piping: ASTM F 493.

2. PVC Piping: ASTM D 2564. Include purple primer according to ASTM F 656.

2.4 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

1. Manufacturers:

(a) Cascade Waterworks Mfg. Co.
(b) Dresser Industries, Inc.; DMD Div.
(c) Ford Meter Box Company, Incorporated (The); Pipe Products Div.
(d) JCM Industries.
(e) Smith-Blair, Inc.
(f) Viking Johnson.

2. Underground Piping NPS 1-1/2 (DN 40) and Smaller: Manufactured fitting or coupling.

3. Underground Piping NPS 2 (DN 50) and Larger: AWWA C219, metal sleeve-type coupling.

4. Aboveground Pressure Piping: Pipe fitting.

B. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Manufacturer:

(a) Eslon Thermoplastics.

C. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

1. Manufacturers:

(a) Cascade Waterworks Mfg. Co.
(b) Fernco, Inc.
(c) Mission Rubber Company.
(d) Plastic Oddities, Inc.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).

1. Manufacturers:

(a) Capitol Manufacturing Co.
(b) Central Plastics Company.
(c) Eclipse, Inc.
(d) Epco Sales, Inc.
(e) Hart Industries, International, Inc.
(f) Watts Industries, Inc.; Water Products Div.
(g) Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.

1. Manufacturers:

(a) Capitol Manufacturing Co.
(b) Central Plastics Company.
(c) Epco Sales, Inc.
(d) Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Manufacturers:

(a) Advance Products & Systems, Inc.
(b) Calpico, Inc.
(c) Central Plastics Company.
(d) Pipeline Seal and Insulator, Inc.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

1. Manufacturers:

(a) Calpico, Inc.
(b) Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

1. Manufacturers:

(a) Perfection Corp.
(b) Precision Plumbing Products, Inc.
(c) Sioux Chief Manufacturing Co., Inc.
(d) Victaulic Co. of America.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
1. Manufacturers:

(a) Advance Products & Systems, Inc.
(b) Calpico, Inc.
(c) Metraflex Co.
(d) Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM or interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

3. Pressure Plates: Stainless steel Include two for each sealing element.

4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. General

1. Provide sleeves for each pipe passing through walls, partitions, floors, and roofs.

B. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

C. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

D. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

E. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

F. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.

G. PVC Pipe: ASTM D 1785, Schedule 40.

H. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

I. Sleeve Materials

Type Designation	
1	Galvanized steel sheet.
2	Standard weight galvanized steel pipe.
3	Standard weight galvanized steel pipe 1/4" steel plate extending from outside of sleeve a minimum of 2" all around, similar to F&S Mfg. Corp. Fig. 204.
4	Cast iron pipe sleeve with center flange, similar to James B. Clow & Sons No. F-1430 and F-1435.
5	Standard weight galvanized steel pipe with flashing clamp device welded to pipe sleeve or watertight sleeves, similar to Zurn 195-10 with oakum and lead caulking as required.
6	Metal deck and wall sleeves. Similar to Adjust-to-Crete Manuf., Co.

J. Sleeve Sizes

1. Floors and required fire rated partitions - ½" maximum clearance between outside of pipe (or insulation on insulated pipes) and inside of sleeve.

2. Partitions not fire rated - 1-1/2" maximum clearance between outside of pipe (or insulation on insulated pipes) and inside of sleeve.

K. Sleeve Lengths

Location	Sleeve Length
Floors	Equal to depth of floor construction including finish. In waterproof floor construction sleeves to extend minimum of 2" above finished floor level.
Roofs	Equal to depth of roof construction including insulation.
Walls & Partitions	Equal to depth of construction and terminated flush with finished surfaces.

L. Sleeve Caulking & Packing

Type Designation	Caulking & Packing Requirements
A	Space between pipe and sleeve packed with oakum or hemp and caulked watertight with lead.
B	Space between pipe or pipe covering and sleeve shall be caulked with an incombustible permanently plastic, waterproof non-staining smooth appearance or pack with mineral wool or other equally approved fire resistive material to within ½" of both wall faces and provide caulking compound as per above.

M. Sleeve Application

Sleeve Type Thru Required Fire Rated Construction	Sleeve Type Thru Non-Fire Rated Construction	Location	Sleeve Caulking & Packing Type Designation	Sleeve Caulking & Packing Type Thru Fire Rated Construction
5	5	Membrane waterproof floor,roof & wall con-struction.	B	B

Sleeve

Sleeve Type Thru Required Fire Rated Construction	Sleeve Type Thru Non-Fire Rated Construction	Location	Sleeve Caulking & Packing Type Designation	Caulking & Packing Type Thru Fire Rated Construction
5	5	Non-membrane waterproof floor, roof & wall construction where flashing is required.	A or B	B
2	1, 2	Interior walls, partitions & floors.	B	B
3 or 4	3 or 4	Exterior walls.	A	A
2	6	Cellular metal deck floors.	B	B
1	1	Precast concrete floor with poured concrete topping. Note: Sleeves to have flat flanges and/ or guides which rest on top of precast slab.	B	B

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated.

E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

F. Split-Plate, Stamped-Steel Type: With exposed-rivet hinge, set screw or spring clips, and chrome-plated finish.

G. One-Piece, Floor-Plate Type: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.

2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

3. Packaging: Premixed and factory packaged.

2.10 FIRESTOPPING

A. In addition to fire protection means specified elsewhere in this specification, this trade shall comply with the following.

B. All spaces between pipes and their respective sleeves shall be packed full depth with mineral wool, or other equally fire resistant material, and compressed firmly in place. Fiberglass shall not be used. Sleeve clearances shall not exceed ½ inch between pipes and sleeves. Use individual sleeves for each pipe or duct. Before escutcheons are attached caulking must be available for inspection and notification should be made.

C. Fire Stopping material and installed configuration shall maintain the fire rating of the penetrated wall, floor or ceiling.

D. All pipe penetrations requiring Fire Stopping shall be “UL” approved thru-wall fire stop assemblies.

E. Fire stop assemblies shall be Rectorseal, 3M, Hilti, Tremco or approved equal.

F. Contractor shall provided assembly for each type of pipe material thru fire-rated wall thickness.

G. Fire Stopping assemblies shall be approved by the authority having jurisdiction.

2.11 TOOLS AND LUBRICANTS

A. Furnish special tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.

B. Lubricants: A minimum of one quart of oil, and one pound of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

2.12 ACCESS DOORS IN FINISHED CONSTRUCTION

A. Access doors as required for operation and maintenance of concealed equipment, valves, controls, etc. will be provided by another trade.

1. This Trade is responsible for access door location, size and its accessibility to the valves or equipment being served.

2. Coordinate and prepare a location, size, and function schedule of access doors required and deliver to a representative of the installing trade.

3. Access doors shall be of ample size, minimum of 16" x 16".

2.13 FOUNDATIONS

A. General

1. All equipment, piping, etc., mounted on/or suspended from approved foundations and supports, as specified, as shown on the drawings.

2. All concrete foundations and supports (and required reinforcing and forms) will be provided by another trade. This trade shall furnish shop drawings showing adequate concrete reinforcing steel details and templates for all concrete foundations and supports, and all required hanger bolts and other appurtenances necessary for the proper installation of his equipment. Although another trade will complete all concrete work, all such work shall be shown in detail on the shop drawings, prepared by this trade, which drawings shall be submitted showing the complete details of all foundations including necessary concrete and steel work, etc.

B. In seismic zones, provide lateral support for earthquake forces.

2.14 FOUNDATION

A. For all outdoor applications and all indoor applications in a harsh environment, refer to Section 09 09960 “High Performance Coatings.”

2.15 TOOLS AND LUBRICANTS

A. Furnish special tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery finished.

B. Lubricants: A minimum of one quart of oil, and one pound of grease, of equipment manufacturer's recommended grade type, in unopened containers and properly identified as to use for each different application.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 15 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

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

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

(a) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.

(b) Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.

(c) Insulated Piping: One-piece, stamped-steel type with spring clips.

(d) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.

(e) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.

(f) Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.

(g) Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge and set screw.

(h) Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.

(i) Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed or exposed-rivet hinge and set screw or spring clips.

(j) Bare Piping in Equipment Rooms: One-piece, cast-brass type.

(k) Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.

(l) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

M. Sleeves are not required for core-drilled holes.

N. Permanent sleeves are not required for holes formed by removable PE sleeves.

O. Install sleeves for pipes passing through poured concrete and masonry walls, gypsum-board partitions, and poured concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

(a) Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.

3. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

(a) Steel or Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).

(b) Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.

(c) Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 7 Section "Sheet Metal Flashing and Trim" for flashing.

(1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 7 Section #'s "Joint Sealants" for materials and installation.

P. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.

2. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.

3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

Q. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 7 Section "Through-Penetration Firestop Systems" for materials.

S. Verify final equipment locations for roughing-in.

T. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

U. No installation shall be permitted which blocks or otherwise impedes access to any existing machine or system. Except as otherwise indicated, emergency switches and alarms shall be installed in conspicuous locations. All indicators, to include gauges, meters, and alarms shall be mounted in order to be easily visible by people in the area.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 15 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.

3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.

4. PVC Nonpressure Piping: Join according to ASTM D 2855.

K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.5 PAINTING

A. Painting of mechanical systems, equipment, and components is specified in Division 9 Section.

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

C. Provide prime coat painting for the following:

1. Miscellaneous steel and iron provided by the Plumbing Contractor.

2. Hangers and supports provided by the Plumbing Contractor.

3.6 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.

3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

5. Install anchor bolts to elevations required for proper attachment to supported equipment.

6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 5 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.8 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor mechanical materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.9 GROUTING

A. Mix and install grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.10 TESTS

A. Provide all designating signs for shutoff valves, control valves, alarms, and the like, as required by the agencies having jurisdiction.

B. Testing of Systems

1. Perform all required tests in the manner prescribed by and to the satisfaction of the local building department and local plumbing inspector, Owners Insurance Underwriters, and all authorities having jurisdiction. Owners and Architects representatives shall be present to inspect tests. Obtain all required certificates of approval and pay any fees or costs in conjunction therewith.

2. Provide and pay for all devices, materials, supplies, labor and power required in connection with all tests. All tests shall be made in the presence and to the satisfaction of the Architect and inspectors having jurisdiction.

3. Defects disclosed by the tests shall be repaired, or if required by the Architect, defective work shall be replaced with new work without extra charge to the Owner. Tests shall be repeated as directed, until all work is proven satisfactory.

4. This 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 own work, and he shall, without extra charge to the Owner, restore to its original condition, work of the trades so damaged and disturbed, engaging the original Contractors to do the work of restoration.

3.11 INSTALLATION

A. Coordinate location of piping, sleeves, inserts, hangers and equipment. Locate piping, sleeves, inserts, hangers, and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Follow manufacturer's published recommendations for installation methods not otherwise specified.

3.12 PROTECTION AND CLEANING

A. Cleaning of Piping System (General)

1. During construction, properly cap, plug and cover all openings in pipe, lines and equipment nozzles so as to prevent the entrance of sand, dirt, and foreign matter. Each system of piping shall be flushed (for the purpose of removing grit, dirt, sand, and foreign matter from the piping), for as long a time as is required to thoroughly clean the systems.

B. Adjusting (General)

1. After the entire installation has been completed, make all required adjustments to balancing valves, air vents, automatic controls, circulators, flush valves, faucets, pressure reducing valves, etc., until all performance requirements are met. All water circulating systems shall be properly balanced.

C. All bearings of all equipment shall be oiled or greased as recommended by the manufacturer, after installation.

D. The alignment of each centrifugal pump shall be checked and each pump shall be properly aligned after the pumps are placed in service. Mechanical seals and shaft sleeves shall be replaced by this Contractor without charge in the event that unusual wear or faulty operation occurs during the guarantee period.

E. Cleaning (General)

1. Upon completion of the work, all fixtures, trimmings and equipment shall be thoroughly cleaned, polished and left in first class condition for final acceptance.

3.13 EQUIPMENT PROVIDED UNDER OTHER SECTIONS OF THE WORK THAT REQUIRES PLUMBING

A. Certain equipment may be supplied under other sections of the work. This Contractor shall provide as described below the requirements and all necessary services roughing and final connections as shown on the plans and as required.

B. Installation of the equipment shall be performed in the following manner.

1. Roughing: Provide all water, waste and vent piping complete in accordance with detailed dimensioned drawings, to be provided by the equipment suppliers. This roughing shall be left ready for final connection to tables and equipment terminated at a point and height indicated by the Equipment Suppliers drawings.

2. Setting of Equipment: The Equipment Supplier will furnish and set in place and secure all equipment.

3. Final Connection: This trade shall make all final connections after the equipment has been set in place.

4. Trim: The Equipment Supplier will furnish all specialized appliances and trim such as faucets, tailpieces, strainers, service outlet bibbs, cocks, serrated hose connections and other related trim. This Trade shall coordinate and check with the Equipment Supplier and shall provide all valve, traps, stops, escutcheons, branch control valves, floor and funnel drains, nipples, fittings, tailpieces, pressure reducing valves, vacuum breakers, check valve, and other appurtenances which are not supplied by the Equipment Supplier and are necessary to the operating characteristics of the equipment being furnished. Also install all trim furnished with the equipment, as required, in accordance with the manufacturer's recommendations.

5. All exposed to view final connection piping, fittings, valves, etc., shall be chrome plated with finish matching equipment rim finishes. Submit finish samples to Architect for approval. Attention is hereby drawn to the Equipment Specifications being prepared under other sections of the work.

C. Review all Architectural drawings and equipment cuts for all equipment locations & services required at each piece of equipment.

3.14 EXCAVATION AND BACKFILL

A. Instructions:

1. Trenches shall be excavated so that pipe can be laid to the alignment and depth indicated on the drawings, and shall be excavated only so far in advance of pipe laying as approved.

2. Width of trenches shall be held to a minimum consistent with the type of material encountered and the size of the pipe being laid, but the width at the top of the pipe shall not be more than 2'-0" plus outside diameter of pipe. Excavation for manholes and other accessories shall have 12" minimum and a 24" maximum clearance on all sides.

3. Before fill or backfilling commences, all trash, debris and other foreign material shall be removed from trenches to be backfilled by this Trade. Fill material shall be free from timber, rocks 3" or larger, organic material, frozen material, and other unsuitable material as determined by the Architect. Filling shall not be done in freezing weather, unless specifically approved. No filling shall be done when material already in place is frozen.

4. In filling around pipe, deposit backfill material in successive horizontal layers not exceeding 6" in thickness before compaction. Compact each layer thoroughly by means of approved mechanical tampers. Take special care to obtain compaction under pipe haunches. Deposit backfill adjacent to pipes on both sides to approximately same elevation at the same time. Continue this method of filling and compacting until backfill is at least 18" above top of pipe.

5. Backfilling for the remainder of pipe trenches to subgrades of paved or landscaped areas shall be done by mechanical tamping and rolling equipment, except that the use of such equipment is prohibited when said use may result in damage to pipelines or structures.

6. Backfill shall be moistened as necessary for proper compaction. Water settling of fill will not be permitted.

7. Complete backfilling of pipe trenches as soon as possible after the pipe is laid and tested.

8. Existing pavements, roadways, walkways, curbs and landscaped areas disturbed during the progress of the excavation and backfill work shall be restored to their original condition at no additional cost to the Owner.

9. Backfill shall be compacted to a minimum of 90% of modified AASHO maximum density as defined by ASTM D-1557. Any layer of fill, or portion thereof, which is not compacted to the required density shall be recompacted until the specified density is achieved, or the layer shall be removed.

3.15 APPLIANCES, TOILET ROOM ACCESSORIES AND TRIM

A. Handle and install all Plumbing connected appliances claimed under Plumber's jurisdiction from tailboard delivery, including hoisting and rigging to designated locations.

B. Handle and install all accessories and trim claimed under Plumber's jurisdiction.

C. Dispose of all appliance and accessories packing crates and debris off of the site.

3.16 ARCHITECTURAL COORDINATION AND SAMPLES

A. All devices and appurtenances which are to be installed in all finished areas must be coordinated with the Architect for final approval as it relates to location, finish, materials, color, texture, etc.

B. Submit samples of all materials requested by the Architect.

C. Samples shall be prepared and submitted with all postage and transportation costs paid by the Contractor submitting same. Label each sample with identifying numbers and titles.

D. Submit samples of:

1. All exposed to view finishes such as cleanout plates, access covers, drain grates and tops, fixture trim, fresh air inlet plates, etc.

END OF SECTION 15051

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes basic requirements for factory-installed and field-installed motors.

B. Related Sections include the following:

1. Division 15 Section "Mechanical Vibration and Seismic Controls" for mounting motors and vibration isolation and seismic-control devices.

2. Division 15 Sections for application of motors and reference to specific motor requirements for motor-driven equipment.

1.3 DEFINITIONS

A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.

B. Field-Installed Motor: A motor installed at Project site and not factory installed as an integral component of motorized equipment.

1.4 SUBMITTALS

A. Product Data for Field-Installed Motors: For each type and size of motor, provide nameplate data and ratings; shipping, installed, and operating weights; mounting arrangements; size, type, and location of winding terminations; conduit entry and ground lug locations; and information on coatings or finishes.

B. Shop Drawings for Field-Installed Motors: Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:

1. Each installed unit's type and details.

2. Nameplate legends.

C. Manufacturer Seismic Qualification Certification: Submit certification that motors, accessories, and components will withstand seismic forces defined in Division 15 Section "Mechanical Vibration and Seismic Controls." Include the following:

1. Test Reports: Written reports specified in Parts 2 and 3.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain field-installed motors of a single type through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70, as amended by state and local codes.

1.6 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices. Provide motors that are:

1. Compatible with the following:

(a) Magnetic controllers.
(b) Multispeed controllers.
(c) Reduced-voltage controllers.

2. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.

3. Matched to torque and horsepower requirements of the load.

4. Matched to ratings and characteristics of supply circuit and required control sequence.

B. Coordinate motor support with requirements for driven load; access for maintenance and motor replacement; installation of accessories, belts, belt guards; and adjustment of sliding rails for belt tensioning.

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

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

A. Motor requirements apply to factory-installed and field-installed motors except as follows:

1. Different ratings, performance, or characteristics for a motor are specified in another Section.

2. Manufacturer for a factory-installed motor requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

2.2 MOTOR CHARACTERISTICS

A. Motors ½ HP and Larger: Three phase.

B. Motors Smaller Than ½ HP: Single phase.

C. Frequency Rating: 60 Hz.

D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.

E. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.

F. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) above sea level.

G. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

H. Enclosure: Open dripproof.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design E, medium induction motor. Efficiency in accordance with NEMA standards for Premium Efficient motors and with applicable EPACT Efficiency Standards.

B. Stator: Copper windings, unless otherwise indicated.

1. Multispeed motors shall have separate winding for each speed.

C. Rotor: Squirrel cage, unless otherwise indicated.

D. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading.

E. Temperature Rise: Match insulation rating, unless otherwise indicated.

F. Insulation: Class F, unless otherwise indicated.

G. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or G.

2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

H. Enclosure: Cast iron for motors 7.5 hp and larger; rolled steel for motors smaller than 7.5 hp.

1. Finish: Gray enamel.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Designed with critical vibration frequencies outside operating range of controller output.

2. Temperature Rise: Matched to rating for Class B insulation.

3. Insulation: Class H.

4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

5. Inverter rated: Comply with NEMA MG-1 Part 31.4.4.2 requirements for inverter rated motors.

C. Rugged-Duty Motors: Totally enclosed, with 1.25 minimum service factor, greased bearings, integral condensate drains, and capped relief vents. Windings insulated with nonhygroscopic material.

1. Finish: Chemical-resistant paint over corrosion-resistant primer.

2.5 SINGLE-PHASE MOTORS

A. Type: One of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.

2. Split-phase start, capacitor run.

3. Capacitor start, capacitor run.

B. Shaded-Pole Motors: For motors 1/20 hp and smaller only.

C. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

D. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, prelubricated-sleeve type for other single-phase motors.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive field-installed motors for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in of conduit systems to verify actual locations of conduit connections before motor installation.

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

3.2 MOTOR INSTALLATION

A. Anchor each motor assembly to base, adjustable rails, or other support, arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and align with load transfer link.

B. Install motors on concrete bases complying with Division 3.

C. Comply with mounting and anchoring requirements specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

3.3 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.

2. Test interlocks and control features for proper operation.

3. Verify that current in each phase is within nameplate rating.

B. Testing: Perform the following field quality-control testing:

1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.15.1. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.4 ADJUSTING

A. Align motors, bases, shafts, pulleys and belts. Tension belts according to manufacturer's written instructions.

3.5 CLEANING

A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean motors, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 15055

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes hangers and supports for plumbing system piping and equipment.

B. Related Sections include the following:

1. Division 5 Section Metal Fabrications for materials for attaching hangers and supports to building structure.

2. Division 15 Section 15072 Plumbing - Vibration Controls and Seismic Restraints for vibration isolation and seismic restraint devices.

3. Division 15 Section 15140 Domestic water piping.

4. Division 15 Section 15150 Domestic water piping.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

B. Design heavy-duty steel trapezes for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

C. Design seismic restraint hangers and supports for piping and equipment.

D. Design and obtain approval from authorities having jurisdiction for seismic restraint hangers and supports for piping and equipment.

1.5 SUBMITTALS

A. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer for multiple piping supports and trapeze hangers. Include design calculations and indicate size and characteristics of components and fabrication details.

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

1.6 QUALITY ASSURANCE

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

B. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for each multiple pipe support and trapeze by a qualified professional engineer.

C. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for each multiple pipe support, trapeze, and seismic restraint by a qualified professional engineer.

1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of hangers and supports that are similar to those indicated for this Project in material, design, and extent.

PART 2- PRODUCTS

2.1 MANUFACTURERS

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

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Pipe Hangers:

(a) B-Line Systems, Inc.

(b) Grinnell Corp.

(c) Michigan Hanger Co., Inc.

(d) PHD Manufacturing, Inc.

2. Channel Support Systems:

   (a) B-Line Systems, Inc.

   (b) Grinnell Corp.; Power-Strut Unit.

   (c) Michigan Hanger Co., Inc.; O-Strut Div.

   (d) Thomas & Betts Corp.

   (e) Unistrut Corp.

3. Thermal-Hanger Shield Inserts:

   (a) Carpenter & Patterson, Inc.

   (b) Michigan Hanger Co., Inc.

   (c) PHS Industries, Inc.

   (d) Pipe Shields, Inc.

   (e) Rilco Manufacturing Co., Inc.

4. Powder-Actuated Fastener Systems:

   (a) Gunnebo Fastening Corp.

   (b) Hilti, Inc.

   (c) ITW Ramset/Red Head.

   (d) Masterset Fastening Systems, Inc.

2.2 MANUFACTURED UNITS

A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.

   1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.

   2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.

   1. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.

2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

C. Thermal-Hanger Shield Inserts: 100-psi (690-kPa) minimum compressive-strength insulation, encased in sheet metal shield.

1. Material for Cold Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate with vapor barrier.

2. Material for Cold Piping: ASTM C 552, Type I cellular glass with vapor barrier.

3. Material for Cold Piping: Water-repellent-treated, ASTM C 533, Type I calcium silicate with vapor barrier.

4. Material for Hot Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate.

5. Material for Hot Piping: ASTM C 552, Type I cellular glass.

6. Material for Hot Piping: Water-repellent-treated, ASTM C 533, Type I calcium silicate.

7. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.

8. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of pipe.

9. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.3 MISCELLANEOUS MATERIALS

A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

C. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.

D. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.

1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.

2. Properties: Nonstaining, noncorrosive, and nongaseous.

3. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3- EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.

B. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS ½ to NPS 30 (DN15 to DN750).

2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F (49 to 232 deg C) pipes, NPS 4 to NPS 16 (DN100 to DN400), requiring up to 4 inches (100 mm) of insulation.

3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24 (DN20 to DN600), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.

4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS ½ to NPS 24 (DN15 to DN600), if little or no insulation is required.

5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS ½ to NPS 4 (DN15 to DN100), to allow off-center closure for hanger installation before pipe erection.

6. Adjustable Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8 (DN20 to DN200).

7. Adjustable Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS ½ to NPS 8 (DN15 to DN200).

8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS ½ to NPS 8 (DN15 to DN200).

9. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS ½ to NPS 2 (DN15 to DN50).

10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8 (DN10 to DN200).

11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3 (DN10 to DN80).

12. U-Bolts (MSS Type 24): For support of heavy pipe, NPS ½ to NPS 30 (DN15 to DN750).

13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.

14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36 (DN100 to DN900), with steel pipe base stanchion support and cast-iron floor flange.

15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36 (DN100 to DN900), with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.

16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36 (DN65 to DN900), if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.

17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30 (DN25 to DN750), from two rods if longitudinal movement caused by expansion and contraction might occur.

18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20 (DN65 to DN500), from single rod if horizontal movement caused by expansion and contraction might occur.

19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42 (DN50 to DN1050), if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24 (DN50 to DN600), if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.

21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30 (DN50 to DN750), if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

C. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20 (DN20 to DN500).

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN20 to DN500), if longer ends are required for riser clamps.

D. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.

2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.

3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.

4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.

E. Building Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.

3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.

4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.

6. C-Clamps (MSS Type 23): For structural shapes.

7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.

8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.

9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.

10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.

11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.

12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    (a) Light (MSS Type 31): 750 lb (340 kg).

    (b) Medium (MSS Type 32): 1500 lb (675 kg).

    (c) Heavy (MSS Type 33): 3000 lb (1350 kg).

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where head room is limited.

F. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.

2. Protection Shields (MSS Type 40): Of length recommended by manufacturer to prevent crushing insulation.

3. Thermal-Hanger Shield Inserts: For supporting insulated pipe, 360-degree insert of high-density, 100-psi (690-kPa) minimum compressive-strength, water-repellent-treated calcium silicate or cellular-glass pipe insulation, same thickness as adjoining insulation with vapor barrier and encased in 360-degree sheet metal shield.

G. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.

2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).

3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.

4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.

5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.

6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.

7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.

8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

   (a) Horizontal (MSS Type 54): Mounted horizontally.

   (b) Vertical (MSS Type 55): Mounted vertically.

   (c) Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

3.2 HANGER AND SUPPORT INSTALLATION

A. Pipe Hanger and Support Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

1. Vertical Piping: MSS Type 8 or Type 42, clamps.

2. Individual, Straight, Horizontal Piping Runs: According to the following:

   (a) 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.

   (b) Longer Than 100 Feet (3 m): MSS Type 43, adjustable roller hangers.

   (c) Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

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

B. Support vertical piping and tubing at base and at each floor.

C. Rod diameter may be reduced 1 size for double-rod hangers, to a minimum of 3/8 inch (10 mm).

D. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32) and Smaller: 84 inches (2100 mm) with 3/8-inch (10-mm) rod.

2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.

3. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.

4. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with ½-inch (13-mm) rod.

5. NPS 3 and NPS 3-1/2 (DN 80 and DN 90): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.

6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.

7. NPS 6 (DN 150): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.

8. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.

E. Install supports for vertical steel piping every 15 feet (4.5 m).

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.

2. NPS 3 (DN 80): 60 inches (1500 mm) with ½-inch (13-mm) rod.

3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.

4. NPS 6 (DN 150): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.

5. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.

6. NPS 15 (DN 375): 60 inches (1500 mm) with 1-inch (25-mm) rod.

7. Spacing for 10-foot (3-m) lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).

G. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).

H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.

2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.

3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.

4. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with ½-inch (13-mm) rod.

5. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.

6. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.

7. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

I. Install supports for vertical copper tubing every 10 feet (3 m).

J. Install hangers for CPVC piping with the following maximum horizontal spacing and minimum rod dimeters:

1. NPS 1 (DN 25) and Smaller: 36 inches (900 mm) with 3/8-inch (10-mm) rod.

2. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.

3. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.

4. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.

5. NPS 6 (DN 150): 28 inches (1200 mm) with 3/4-inch (19-mm) rod.

6. NPS 8 (DN 200): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.

K. Install supports for vertical CPVC piping every 60 inches (1500 mm) for NPS 1 (DN 25) and smaller and every 72 inches (1800 mm) for NPS 1-1/4 (DN 32) and larger.

L. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2 (DN 50) and Smaller: 48 inches (1200 mm) with 3/8-inch (10-mm) rod.

2. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.

3. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.

4. NPS 6 (DN 150): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.

5. NPS 8 to NPS 12 (DN 200 to Dn 300): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.

M. Install supports for vertical PVC piping every 48 inches (1200 mm).

N. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.3 HANGER AND SUPPORT INSTALLATION

A. Pipe Hanger and Support Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Channel Support System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.

1. Field assemble and install according to manufacturer's written instructions.

C. Heavy-Duty Steel Trapeze Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated, heavy-duty trapezes.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.

2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.

D. Install building attachments within concrete slabs or attach to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

E. Install powder-actuated drive-pin fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

F. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

J. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.

K. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.

   (a) Piping Operating above Ambient Air Temperature: Clamp may project through insulation.

   (b) Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.

   (c) Do not exceed pipe stress limits according to ASME B31.9.

2. Install MSS SP-58, Type 39 protection saddles, if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

   (a) Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN100) and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span arc of 180 degrees.

   (a) Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN100) and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

   (a) NPS 1/4 to NPS 3-1/2 (DN8 to DN90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.

   (b) NPS 4 (DN100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.

   (c) NPS 5 and NPS 6 (DN125 and DN150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.

(d) NPS 8 to NPS 14 (DN200 to DN350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.

(e) NPS 16 to NPS 24 (DN400 to DN600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.

5. Pipes NPS 8 (DN200) and Larger: Include wood inserts.

6. Insert Material: Length at least as long as protective shield.

7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.4 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.5 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.

B. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.6 ADJUSTING

A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.7 PAINTING

A. Touching Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 Section "Painting."

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 15061

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following mechanical identification materials and their installation:

1. Equipment nameplates.

2. Pipe markers.

3. Valve tags.

4. Valve schedules.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.5 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.

1. Data:

(a) Manufacturer, product name, model number, and serial number.

(b) Capacity, operating and power characteristics, and essential data.

(c) Labels of tested compliances.

2. Location: Accessible and visible.

3. Fasteners: As required to mount on equipment.

B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.

1. Terminology: Match schedules as closely as possible.

2. Data:

(a) Name and plan number.

(b) Equipment service.

(c) Design capacity.

(d) Other design parameters such as pressure drop, entering and leaving conditions, and speed.

3. Size: 2-1/2 by 4 inches (64 by 100 mm) for control devices, dampers, and valves; 4-1/2 by 6 inches (115 by 150 mm) for equipment.

C. Access Panel and Door Markers: 1/16-inch- (1.6-mm-) thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch (3.2-mm) center hole for attachment.

1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.2 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.

1. Colors: Comply with ASME A13.1, unless otherwise indicated.

2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.

3. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Full-band pipe markers extending 360 degrees around pipe at each location.

4. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.

5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.

B. Pretensioned Pipe Markers: Precoiled semirigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.

C. Shaped Pipe Markers: Preformed semirigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.

D. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.

E. Plastic Tape: Continuously printed, vinyl tape at least 3 mils (0.08 mm) thick with pressure-sensitive, permanent-type, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): 3/4 inch (19 mm) minimum.

2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

2.3 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers. Provide 5/32-inch (4-mm) hole for fastener.

1. Material: 0.032-inch- (0.8-mm-) thick brass.

2. Valve-Tag Fasteners: Brass wire-link or S-hook.

2.4 VALVE SCHEDULES

A. Valve Schedules: For each piping system, on standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.

2. Frame: Extruded aluminum.

3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other Division 15 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:

1. Pumps, compressors and similar motor-driven units.

2. Water heaters, heat exchangers, etc.

B. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.

1. Letter Size: Minimum 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), ½ inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.

3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:

(a) Main control and operating valves, including safety devices and hazardous units such as gas outlets.

(b) Meters, gages, thermometers, and similar units.

(c) Fuel-burning units, including water heaters and heat exchangers.

(d) Pumps, compressors, and similar motor-driven units.

(e) Tanks and pressure vessels.

(f) Strainers, filters, water-treatment systems, and similar equipment.

C. Install access panel markers with screws on equipment access panels.

3.3 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.

1. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Pretensioned pipe markers. Use size to ensure a tight fit.

2. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, [at least 3/4 inch (19 mm)] [1-1/2 inches (38 mm)] wide, lapped at least 1-1/2 inches (38 mm) at both ends of pipe marker, and covering full circumference of pipe.

3. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Shaped pipe markers. Use size to match pipe and secure with fasteners.

4. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 1-1/2 inches (38 mm) wide, lapped at least 3 inches (75 mm) at both ends of pipe marker, and covering full circumference of pipe.

B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed locations as follows:

1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.

3. Near penetrations through walls, floors, ceilings, and nonaccessible enclosures.

4. At access doors, manholes, and similar access points that permit view of concealed piping.

5. Near major equipment items and other points of origination and termination.

6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.

7. On piping above removable acoustical ceilings. Omit intermediately spaced markers.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; plumbing fixture supply stops; shutoff valves; faucets; convenience and lawn-watering hose connections; and terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

TAGS SHOULD HAVE SYSTEM IDENTIFICATION STAMPED ON TAG

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following:

1. Valve-Tag Size and Shape:

(a) Cold Water: 1-1/2 inches (38 mm) or 2 inches (50 mm), round

(b) Hot Water: 1-1/2 inches (38 mm) or 2 inches (50 mm), round

(c) Gas: 1-1/2 inches (38 mm) or 2 inches (50 mm), round

2. Valve-Tag Color:

(a) Cold Water: Natural.

(b) Hot Water: Natural.

(c) Gas: Natural.

3. Letter Color:

(a) Cold Water: Black or White.

(b) Hot Water: Black or White.

(c) Gas: Black or White.

3.5 VALVE-SCHEDULE INSTALLATION

A. Mount valve schedule on wall in accessible location in each major equipment room.

3.6 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work

3.7 CLEANING

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION 15075

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes preformed, rigid and flexible pipe insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

B. Related Sections include the following:

1. Division 7 Section "Firestopping" for firestopping materials and requirements for penetrations through fire and smoke barriers.

2. Division 15 Section "Hangers and Supports" for pipe insulation shields and protection saddles.

1.3 SUBMITTALS

A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.

B. Shop Drawings: Show fabrication and installation details for the following:

1. Application of protective shields, saddles, and inserts at pipe hangers for each type of insulation and hanger.

2. Attachment and covering of heat trace inside insulation.

3. Insulation application at pipe expansion joints for each type of insulation.

4. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.

5. Removable insulation at piping specialties and equipment connections.

6. Application of field-applied jackets.

C. Samples: For each type of insulation and jacket. Identify each Sample, describing product and intended use. Submit Samples in the following sizes:

1. Preformed Pipe Insulation Materials: 12 inches (300 mm) long by NPS 2 (DN50).

2. Sheet Form Insulation Materials: 12 inches (300 mm) square.
3. Jacket Materials: 12 inches (300 mm) long by NPS 2 (DN50).

4. Manufacturer's Color Charts: Show the full range of colors available for each type of field-applied finish material indicated.

D. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets with requirements indicated. Include dates of tests.

E. Installer Certificates: Signed by the Contractor certifying that installers comply with requirements.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.

2. Insulation Installed Outdoors: Flame-spread rating of 75 or less, and smoke-developed rating of 150 or less.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups according to the following requirements, using materials indicated for the completed Work:

1. Include the following mockups:

(a) One 10-foot (3-m) section of NPS 2 (DN50) straight pipe.

(b) One 90-degree elbow.

(c) One tee fitting.

(d) One NPS 2 (DN50) valve.

(e) Four support hangers, including hanger shield and insert.

(f) One strainer with removable portion of insulation.

(g) One reducer.

2. Build mockups with cutaway sections to allow observation of application details for insulation materials, mastics, attachments, and jackets.

3. Build mockups in the location indicated or, if not indicated, as directed by Architect.

4. Notify Architect seven days in advance of dates and times when mockups will be constructed.

5. Obtain Architect's approval of mockups before starting insulation application.

6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.

7. Demolish and remove mockups when directed.

8. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 15 Section "Hangers and Supports."

B. Coordinate clearance requirements with piping Installer for insulation application.

C. Coordinate installation and testing of steam or electric heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after testing piping systems and, where required, after installing and testing heat-trace tape. Insulation application may begin on segments of piping that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Mineral-Fiber Insulation:

    (a) CertainTeed Manson.

    (b) Knauf FiberGlass GmbH.
    (c) Owens-Corning Fiberglas Corp.

    (d) Schuller International, Inc.

2. Cellular-Glass Insulation:

    (a) Pittsburgh-Corning Corp.

3. Insulation:

    (a) Armstrong World Industries, Inc.

    (b) IMCOA.

4. Phenolic-Foam Insulation:

    (a) Kooltherm Insulation Products, Ltd.

5. Calcium Silicate Insulation:

    (a) Owens-Corning Fiberglas Corp.

    (b) Pabco.

    (c) Schuller International, Inc.

2.2 INSULATION MATERIALS

A. Type A - Mineral-Fiber Insulation: Glass fibers bonded with a thermosetting resin complying with the following:

1. Preformed Pipe Insulation: Comply with ASTM C 547, Type 1, with factory-applied, all-purpose, vapor-retarder jacket.

2. Blanket Insulation: Comply with ASTM C 553, Type II, without facing.

3. Fire-Resistant Adhesive: Comply with MIL-A-3316C in the following classes and grades:

    (a) Class 1, Grade A for bonding glass cloth and tape to unfaced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to unfaced glass-fiber insulation.

    (b) Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.

4. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.

5. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.

6. Expanded or Exfoliated Vermiculite Insulating Cements: Comply with ASTM C 196.

7. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

B. Type B - Cellular-Glass Insulation: Inorganic, foamed or cellulated glass, annealed, rigid, hermetically sealed cells, incombustible.

1. Preformed Pipe Insulation, without Jacket: Comply with ASTM C 552, Type II, Class 1.

2. Preformed Pipe Insulation, with Jacket: Comply with ASTM C 552, Type II, Class 2.

C. Closed-Cell Phenolic-Foam Insulation: Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.

D. Type C - Calcium Silicate Insulation: Preformed pipe sections of noncombustible, inorganic, hydrous calcium silicate with a nonasbestos fibrous reinforcement. Comply with ASTM C 533, Type I.

E. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

2.3 INSULATION FOR PIPING AND EQUIPMENT

A. Piping and equipment shall be insulated in accordance with the following schedule: See paragraph 2.2 for Type

Service	Thickness and Type #	Notes
Domestic and non-potable hot water, hot water circulation mains, risers & branches.	1" Type 2.2-B Local branch piping to main, for ½" & 3/4" size maximum	
Exposed to freezing hot and cold, circulation domestic and non-potable mains, risers and branches.	1" Type 2.2-B 1" to 6" in size. 1½" Type 2.2-B 8" and larger in size	

Service	Thickness and Type #	Notes
Domestic, and non-potable cold water mains, risers, branches & pump discharge piping. All piping on factory packaged pumps.	½" Type 2.2-B	
Horizontal storm water piping and drain bodies interior and exterior	1" Type 2.2-B/ blanket may be used in non exposed areas only	Insulate all horizontal storm water piping & offsets from roof, deck, etc. drain to vertical leaders including drain bodies. Insulate all storm water piping located above hung ceilings.
Water meter assembly	1" Type 2.2-A blanket	Insulate as required by local governing authority.
Chilled drinking water drainage piping from fixture to vertical stack. Fixture tailpiece, trap hot and cold riser.	1½" Type 2.2-B 2½" and larger in size As per authority having jurisdiction	
Sanitary exposed to freezing and traps w/ heat tracing	1" type 2.2C w/ .016" aluminum jacket	
Horizontal waste drain lines from floor or funnel drains in Mechanical Equipment Rooms to point of connection to vertical stack.	1" Type 2.2-A	
Piping provided with Electric Heating Cable as per manufacturer's recommendations.		

2.4 FIELD-APPLIED JACKETS

A. General: ASTM C 921, Type 1, unless otherwise indicated.

B. Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.

C. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils (0.5 mm) thick; roll stock ready for shop or field cutting and forming.

1. Adhesive: As recommended by insulation material manufacturer.

2. PVC Jacket Color: White or gray.

3. PVC Jacket Color: Color-code piping jackets based on materials contained within the piping system.

D. Heavy PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 30-mil- (0.75-mm-) thick, high-impact, ultraviolet-resistant PVC.

1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.

2. Adhesive: As recommended by insulation material manufacturer.

E. Standard PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil- (0.5-mm-) thick, high-impact, ultraviolet-resistant PVC.

1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.

2. Adhesive: As recommended by insulation material manufacturer.

F. Aluminum Jacket: Factory cut and rolled to indicated sizes. Comply with ASTM B 209 (ASTM B 209M), 3003 alloy, H-14 temper.

G. Aluminum Jacket: Aluminum roll stock, ready for shop or field cutting and forming to indicated sizes. Comply with ASTM B 209 (ASTM B 209M), 3003 alloy, H-14 temper.

1. Finish and Thickness: Smooth finish, 0.010 inch (0.25 mm) thick.

2. Finish and Thickness: Corrugated finish, 0.010 inch (0.25 mm) thick.

3. Finish and Thickness: Stucco-embossed finish, 0.016 inch (0.40 mm) thick.

4. Finish and Thickness: Painted finish, 0.016 inch (0.40 mm) thick.

5. Moisture Barrier: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.

6. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.

H. Stainless-Steel Jacket: ASTM A 666, Type 304 or 316; 0.10 inch (2.5 mm) thick; and factory cut and rolled to indicated sizes.

I. Stainless-Steel Jacket: ASTM A 666, Type 304 or 316; 0.10 inch (2.5 mm) thick; and roll stock ready for shop or field cutting and forming to indicated sizes.

1. Moisture Barrier: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.

2. Moisture Barrier: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.

3. Elbows: Gore type, for 45- and 90-degree elbows in same material, finish, and thickness as jacket.

4. Jacket Bands: Stainless steel, Type 304, 3/4 inch (19 mm) wide.

2.5 ACCESSORIES AND ATTACHMENTS

A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 8 oz./sq. yd. (270 g/sq. m).

1. Tape Width: 4 inches (100 mm).

B. Bands: 3/4 inch (19 mm) wide, in one of the following materials compatible with jacket:

1. Stainless Steel: ASTM A 666, Type 304; 0.020 inch (0.5 mm) thick.

2. Galvanized Steel: 0.005 inch (0.13 mm) thick.

3. Aluminum: 0.007 inch (0.18 mm) thick.

4. Brass: 0.010 inch (0.25 mm) thick.
5. Nickel-Copper Alloy: 0.005 inch (0.13 mm) thick.

C. Wire: 0.080-inch (2.0-mm), nickel-copper alloy; 0.062-inch (1.6-mm), soft-annealed, stainless steel; or 0.062-inch (1.6-mm), soft-annealed, galvanized steel.

2.6 VAPOR RETARDERS

A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

2.7 WEATHERPROOFING FINISHES FOR OUTDOOR INSULATION

A. Outside Piping

1. Finish with a .016" thick aluminum jacket which has a factory applied moisture barrier. For all applications where it is available, the jacketing shall be factory attached to the insulation and installed per manufacturers recommendation.

2. Where field applied jacketing must be used, it shall be applied with 2" overlap facing down from the weather and shall be secured with an aluminum band (½" x .020") and seals applied on 12" center with bands applied directly over butt overlaps.

3. Fittings and valves shall be insulated and finished with mitered sections of the insulation with factory attached aluminum jackets installed per manufacturers recommendation.

2.8 PIPING INSULATION FOR ELECTRICALLY TRACED PIPING

A. Provide insulation of thickness shown for piping which is to be electrically traced. Note that insulation is provided by this trade over electric tracing provided by the electrical trade. Insulation types, see paragraph 2.3.

B. The following piping shall be specially insulated:

System	Area
Domestic Water	Outdoors or in unheated areas subject to freezing and other areas where indicated.
Sanitary Drainage Pipe and Traps	" "
Storm Water Drainage Piping	" "

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

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

3.2 PREPARATION

A. Surface Preparation: Clean and dry pipe and fitting surfaces. Remove materials that will adversely affect insulation application.

3.3 GENERAL APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each piping system.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.

E. Apply multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

H. Keep insulation materials dry during application and finishing.

I. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

J. Apply insulation with the least number of joints practical.

K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated. Refer to special instructions for applying insulation over fittings, valves, and specialties.

L. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic.

1. Apply insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor retarders are indicated, extend insulation on anchor legs at least 12 inches (300 mm) from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.

M. Insulation Terminations: For insulation application where vapor retarders are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.

O. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.

2. Circumferential Joints: Cover with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4 inches (100 mm) o.c.

3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches (40 mm). Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches (100 mm) o.c.

(a) Exception: Do not staple longitudinal laps on insulation having a vapor retarder.

4. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.

5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retarder mastic.

P. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.

1. Seal penetrations with vapor-retarder mastic.

2. Apply insulation for exterior applications tightly joined to interior insulation ends.

3. Extend metal jacket of exterior insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.

4. Seal metal jacket to roof flashing with vapor-retarder mastic.

Q. Exterior Wall Penetrations: For penetrations of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retarder mastic.

R. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.

S. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.

1. Firestopping and fire-resistive joint sealers are specified in Division 7 Section "Firestopping."

T. Floor Penetrations: Apply insulation continuously through floor assembly.

1. For insulation with vapor retarders, seal insulation with vapor-retarder mastic where floor supports penetrate vapor retarder.

3.4 MINERAL-FIBER INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of preformed pipe insulation to pipe with wire, tape, or bands without deforming insulation materials.

2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20 feet (4.5 to 6 m) to form a vapor retarder between pipe insulation segments.

3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches (150 mm) o.c.

4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.

4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch (25 mm), and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.

3. Cover fittings with standard PVC fitting covers.

4. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets at least 1 inch (25 mm) at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to stainer basket without disturbing insulation.

3. Apply insulation to flanges as specified for flange insulation application.

4. Use preformed standard PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

5. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

6. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.5 CELLULAR-GLASS INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of insulation to pipe with wire, tape, or bands without deforming insulation materials.

2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic.
3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches (150 mm) o.c.

4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of the same thickness as pipe insulation.

4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch (25 mm), and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded sections of insulation are not available, apply mitered sections of cellular-glass insulation. Secure insulation materials with wire, tape, or bands.

3. Cover fittings with standard PVC fitting covers.

4. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets at least 1 inch (25 mm) at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded segments of cellular-glass insulation or glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to stainer basket without disturbing insulation.

2. Apply insulation to flanges as specified for flange insulation application.

3. Use preformed standard PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories.

Seal seams with tape and vapor-retarder mastic.

4. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

5. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.6 CLOSED-CELL PHENOLIC-FOAM INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of insulation to pipe with wire, tape, or bands without deforming insulation materials.

2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic.

3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches (150 mm) o.c.

4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of the same material and thickness as pipe insulation.

4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch (25 mm), and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded sections of insulation are not available, apply mitered sections of phenolic-foam insulation. Secure insulation materials with wire, tape, or bands.

3. Cover fittings with standard PVC fitting covers.

4. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets at least 1 inch (25 mm) at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded sections of insulation are not available, apply mitered segments of phenolic-foam insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to stainer basket without disturbing insulation.

3. Apply insulation to flanges as specified for flange insulation application.

4. Use preformed standard PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

5. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

6. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.7 CALCIUM SILICATE INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of insulation to pipe with stainless-steel bands at 12-inch (300-mm) intervals and tighten without deforming insulation materials.

2. Apply two-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with 0.062-inch (1.6-mm), soft-annealed, stainless-steel wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.

3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to surface of installed insulation. When dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth or tape. Thin the finish coat to achieve smooth finish.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of the same material and thickness as pipe insulation.

4. Finish flange insulation the same as pipe insulation.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded sections of insulation are not available, apply mitered sections of calcium silicate insulation. Secure insulation materials with stainless-steel wire.

3. Finish insulation of fittings the same as pipe insulation.

D. Apply insulation to valves and specialties as follows:

1. Apply mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to stainer basket without disturbing insulation.

2. Apply insulation to flanges as specified for flange insulation application.

3. Finish valve and specialty insulation the same as pipe insulation.

3.8 FIELD-APPLIED JACKET APPLICATION

A. Apply glass-cloth jacket, where indicated, directly over bare insulation or insulation with factory-applied jackets.

1. Apply jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.

2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of jacket manufacturer's recommended adhesive.

3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.

B. Foil and Paper Jackets: Apply foil and paper jackets where indicated.

1. Draw jacket material smooth and tight.

2. Apply lap or joint strips with the same material as jacket.

3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Apply jackets with 1-1/2-inch (40-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-retarder mastic.

C. Apply PVC jacket where indicated, with 1-inch (25-mm) overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

D. Apply metal jacket where indicated, with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

3.9 FINISHES

A. Glass-Cloth Jacketed Insulation: Paint insulation finished with glass-cloth jacket as specified in Division 9 Section "Painting."

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of the insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

3.10 PIPING SYSTEM APPLICATIONS

A. Insulation materials and thicknesses are specified in schedules at the end of this Section.

B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:

1. Flexible connectors.

2. Vibration-control devices.

3. Drainage piping located in crawl spaces, unless otherwise indicated.

4. Below-grade piping, unless otherwise indicated.

5. Chrome-plated pipes and fittings, unless potential for personnel injury.

6. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

3.11 FIELD QUALITY CONTROL

A. Inspection: Owner will engage a qualified inspection agency to perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:

B. Inspection: Engage a qualified inspection agency to perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:

C. Inspection: Perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:

1. Inspect fittings and valves randomly selected by Architect.

2. Remove fitting covers from 20 elbows or 1 percent of elbows, whichever is less, for various pipe sizes.

3. Remove fitting covers from 20 valves or 1 percent of valves, whichever is less, for various pipe sizes.

D. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.

E. Reinstall insulation and covers on fittings and valves uncovered for inspection according to these Specifications.

3.12 INSULATION APPLICATION SCHEDULE, GENERAL

A. Refer to insulation application schedules for required insulation materials, vapor retarders, and field-applied jackets.

B. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements.

3.13 INTERIOR INSULATION APPLICATION SCHEDULE

A. Service: Domestic hot and recirculated hot water.

1. Operating Temperature: 60 to 140 deg F (15 to 60 deg C).

2. Insulation Material: See paragraph 2.3.

3. Insulation Thickness: See paragraph 2.3.

4. Field-Applied Jacket: Foil and paper

5. Vapor Retarder Required: Yes.

6. Finish: None.

B. Service: Stormwater conductors.

1. Operating Temperature: 32 to 100 deg F (0 to 38 deg C).

2. Insulation Material: See paragraph 2.3.

3. Insulation Thickness: See paragraph 2.3. Apply the following insulation thicknesses:

4. Field-Applied Jacket: Foil and paper

5. Vapor Retarder Required: Yes.

6. Finish: None.

C. Service: Roof drain bodies.

1. Operating Temperature: 32 to 100 deg F (0 to 38 deg C).

2. Insulation Material: See paragraph 2.3.

3. Insulation Thickness: See paragraph 2.3.

4. Field-Applied Jacket: Foil and paper

5. Vapor Retarder Required: Yes.

6. Finish: None.

D. Service: Exposed sanitary drains and domestic water supplies and stops for fixtures for the disabled.

1. Operating Temperature: 35 to 120 deg F (2 to 49 deg C).

2. Insulation Material: See paragraph 2.3.

3. Insulation Thickness: See paragraph 2.3.

4. Field-Applied Jacket: PVC P-trap and supply covers.

5. Vapor Retarder Required: No.

6. Finish: Painted.

3.14 EXTERIOR INSULATION APPLICATION SCHEDULE

A. This application schedule is for aboveground insulation outside the building. Loose-fill insulation, for belowground piping, is specified in Division 2 piping distribution Sections.

B. Service: Domestic water.

1. Operating Temperature: 60 to 140 deg F (15 to 60 deg C).

2. Insulation Material: See paragraph 2.3.

3. Insulation Thickness: See paragraph 2.3.

4. Field-Applied Jacket: Aluminum.

5. Vapor Retarder Required: Yes.

6. Finish: None.

C. Service: Storm water and sanitary drainage piping.

1. Operating Temperature: 32 to 100 deg F (0 to 38 deg C).

2. Insulation Material: See paragraph 2.3.

3. Insulation Thickness: See paragraph 2.3.

4. Field-Applied Jacket None.

5. Vapor Retarder Required: Yes

6. Finish: None.

END OF SECTION 15083

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. The valve schedule on the drawing indicates the particular valve desired at the various locations indicated. Corresponding valves as made by approved manufacturers may be submitted for approval.

B. This Section includes the following valves:

1. Copper-alloy ball valves.
2. Ferrous-alloy ball valves.
3. Ferrous-alloy butterfly valves.
4. High-pressure butterfly valves.
5. Bronze check valves.
6. Gray-iron swing check valves.
7. Bronze gate valves.
8. Cast-iron gate valves.
9. Cast-iron plug valves.
10. Resilient-seated, cast-iron, eccentric plug valves.
11. Chainwheel actuators.
12. Backflow preventors.
13. Water regulators.
14. Balancing valves.
15. Drain valves.
16. Strainers.

C. Related Sections include the following:

1. Division 2 piping Sections for general-duty and specialty valves for site construction piping.

2. Division 15, Section 15051 Basic Plumbing Materials, Methods and Requirements.

3. Division 15 Section 15075 Plumbing Identification for valve tags and charts.

1.3 DEFINITIONS

A. The following are standard abbreviations for valves:

1. CWP: Cold working pressure.

2. EPDM: Ethylene-propylene-diene terpolymer rubber.

3. NBR: Acrylonitrile-butadiene rubber.

4. PTFE: Polytetrafluoroethylene plastic.

5. SWP: Steam working pressure.

6. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

B. Maintenance Data: For plumbing specialties to include in maintenance manuals. Include the following:

1. Backflow preventers and water regulators.

2. Balancing valves.

1.5 QUALITY ASSURANCE

A. ASME Compliance: ASME B31.1 for power piping valves and ASME B31.9 for building services piping valves.

1. Exceptions: Domestic hot- and cold-water piping valves unless referenced.

B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

C. NSF Compliance: NSF 61 for valve materials for potable-water service.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.

2. Protect threads, flange faces, grooves, and weld ends.

3. Set angle, gate, and globe valves closed to prevent rattling.

4. Set ball and plug valves open to minimize exposure of functional surfaces.

5. Set butterfly valves closed or slightly open.

6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.

2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the manufacturers specified.

2.2 VALVES, GENERAL

A. Refer to Part 3 "Valve Applications" Article for applications of valves.

B. All valves shall have manufacturer name and pressure rating cast or stamped thereon. All valves shall be rated for system pressure they are used for.

C. Furnish one manufacturer’s guarantee for all valves.

D. Ball valves may be used on NPS 2 (DN 50) or less in size. Valves shall be two piece full-port brass and rated for 600 psi with maximum drop of 1 psi through valve.

E. Bronze Valves: NPS 2 (DN 50) and smaller with threaded ends, unless otherwise indicated.

F. Ferrous Valves: NPS 2-1/2 (DN 65) and larger with flanged ends, unless otherwise indicated.

G. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

H. Valve Actuators:

1. Chainwheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in Part 3.

2. Gear Drive: For quarter-turn valves NPS 8 (DN 200) and larger.

3. Handwheel: For valves other than quarter-turn types.

4. Lever Handle: For quarter-turn valves NPS 6 (DN 150) and smaller, except plug valves.

5. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug head.

I. Extended Valve Stems: On insulated valves.

J. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.

K. Valve Grooved Ends: AWWA C606.

L. Solder Joint Ends: With sockets according to ASME B16.18.

1. Caution: Use solder with melting point below 840 deg F (454 deg C) for angle, check, gate, and globe valves; below 421 deg F (216 deg C) for ball valves.

M. Threaded Ends: With threads according to ASME B1.20.1.

N. Valve Bypass and Drain Connections: MSS SP-45.

O. Valve seals/packing shall not contain asbestos or other deleterious material. Valve packing for domestic water systems shall meet all AWWA requirements for potable water service.

2.3 BALL VALVES

A. Manufacturers:

1. Ball Valves:

(a) Conbraco Industries, Inc.; Apollo Div.

(b) Crane Co.; Crane Valve Group; Stockham Div.

(c) Grinnell Corporation.

(d) NIBCO INC.

(e) Watts Industries, Inc.; Water Products Div.

2.4 FERROUS-ALLOY BUTTERFLY VALVES

A. Manufacturers:

1. Flangeless Butterfly Valves:

(a) Bray International, Inc.

(b) Crane Co.; Crane Valve Group; Center Line.

(c) Crane Co.; Crane Valve Group; Stockham Div.

(d) Dover Corp.; Dover Resources Company; Norriseal Div.

(e) General Signal; DeZurik Unit.

(f) Grinnell Corporation.

(g) Hammond Valve.

(h) Milwaukee Valve Company.

(i) NIBCO INC.

(j) Watts Industries, Inc.; Water Products Div.

2. Single-Flange Butterfly Valves:

(a) Bray International, Inc.

(b) Crane Co.; Crane Valve Group; Center Line.

(c) Crane Co.; Crane Valve Group; Stockham Div.

(d) Dover Corp.; Dover Resources Company; Norriseal Div.

(e) General Signal; DeZurik Unit.

(f) Grinnell Corporation.

(g) Hammond Valve.

(h) Milwaukee Valve Company.

(i) NIBCO INC.

3. Flanged Butterfly Valves:

(a) Bray International, Inc.

(b) Grinnell Corporation.

(c) Mueller Steam Specialty.

4. Grooved-End, Ductile-Iron Butterfly Valves:

(a) Grinnell Corporation.

(b) McWane, Inc.; Kennedy Valve Div.

(c) Milwaukee Valve Company.

(d) NIBCO INC.

(e) Victaulic Co. of America.

2.5 HIGH-PRESSURE BUTTERFLY VALVES

A. Manufacturers:

1. Bray International, Inc.

2. General Signal; DeZurik Unit.

3. Grinnell Corporation.

4. Pratt, Henry Company.

5. Xomox Corporation.

B. High-Pressure Butterfly Valves, General: MSS SP-68.

C. Flangeless, Class 150, High-Pressure Butterfly Valves: Wafer type.

D. Single-Flange, Class 150, High-Pressure Butterfly Valves: Wafer type.

2.6 BRONZE CHECK VALVES

A. Manufacturers:

1. Bronze, Horizontal Lift Check Valves:
   (a) Crane Co.; Crane Valve Group; Crane Valves.
   (b) Crane Co.; Crane Valve Group; Stockham Div.
   (c) Walworth Co.
2. Bronze, Swing Check Valves:
   (a) Crane Co.; Crane Valve Group; Stockham Div.
   (b) Grinnell Corporation.
   (c) Hammond Valve.
   (d) Milwaukee Valve Company.
   (e) NIBCO INC.
   (f) Watts Industries, Inc.; Water Products Div.

B. Bronze Check Valves, General: MSS SP-80.

2.7 GRAY-IRON SWING CHECK VALVES

A. Manufacturers:

1. Gray-Iron Swing Check Valves:
   (a) Crane Co.; Crane Valve Group; Stockham Div.
   (b) Grinnell Corporation.
   (c) Hammond Valve.
   (d) Milwaukee Valve Company.
   (e) Mueller Co.
   (f) NIBCO INC.
2. Grooved-End, Ductile-Iron Swing Check Valves:
   (a) Grinnell Corporation.
   (b) Mueller Co.
   (c) Victaulic Co. of America.

B. Gray-Iron Swing Check Valves, General: MSS SP-71.

C. Type I, Class 125, gray-iron, swing check valves with metal seats.

D. Type II, Class 125, gray-iron, swing check valves with composition to metal seats.

E. 175-psig (1207-kPa) CWP Rating, Grooved-End, Swing Check Valves: Ductile-iron body with grooved or shouldered ends.

2.8 BRONZE GATE VALVES

A. All gate valves inside the building 4" and over shall be of the OS&Y type except where space conditions do not permit the installation of this type of valve.

B. Available Manufacturers:

1. Type 1, Bronze, Nonrising-Stem Gate Valves:

(a) Crane Co.; Crane Valve Group; Stockham Div.

(b) Grinnell Corporation.

(c) Hammond Valve.

(d) Milwaukee Valve Company.

(e) NIBCO INC.

(f) Watts Industries, Inc.; Water Products Div.

2. Type 2, Bronze, Rising-Stem, Solid-Wedge Gate Valves:

(a) Crane Co.; Crane Valve Group; Stockham Div.

(b) Grinnell Corporation.

(c) Hammond Valve.

(d) Milwaukee Valve Company.

(e) NIBCO INC.

3. Type 3, Bronze, Rising-Stem, Split-Wedge Gate Valves:

(a) Grinnell Corporation.

(b) NIBCO INC.

C. Bronze Gate Valves, General: MSS SP-80, with ferrous-alloy handwheel.

D. Type 1, Class 125, Bronze Gate Valves: Bronze body with nonrising stem and bronze solid wedge and union-ring bonnet.

E. Type 1, Class 150, Bronze Gate Valves: Bronze body with nonrising stem and bronze solid wedge and union-ring bonnet.

F. Type 2, Class 125, Bronze Gate Valves: Bronze body with rising stem and bronze solid wedge and union-ring bonnet.

G. Type 2, Class 150, Bronze Gate Valves: Bronze body with rising stem and bronze solid wedge and union-ring bonnet.

H. Type 3, Class 125, Bronze Gate Valves: Bronze body with rising stem and bronze split wedge and union-ring bonnet.

I. Type 3, Class 150, Bronze Gate Valves: Bronze body with rising stem and bronze split wedge and union-ring bonnet.

2.9 CAST-IRON GATE VALVES

A. All gate valves inside the building 4" and over shall be of the OS&Y type except where space conditions do not permit the installation of this type of valve.

B. Manufacturers:

1. Type I, Cast-Iron, Nonrising-Stem Gate Valves:

    (a) Crane Co.; Crane Valve Group; Stockham Div.

    (b) Grinnell Corporation.

    (c) Hammond Valve.

    (d) Milwaukee Valve Company.

    (e) NIBCO INC.

    (f) Watts Industries, Inc.; Water Products Div.

2. Type I, Cast-Iron, Rising-Stem Gate Valves:

    (a) Crane Co.; Crane Valve Group; Stockham Div.

    (b) Grinnell Corporation.

    (c) Hammond Valve.

    (d) Milwaukee Valve Company.

    (e) NIBCO INC.

    (f) Watts Industries, Inc.; Water Products Div.

C. Cast-Iron Gate Valves, General: MSS SP-70, Type I.

D. Class 125, NRS, Bronze-Mounted, Cast-Iron Gate Valves: Cast-iron body with bronze trim, nonrising stem, and solid-wedge disc.

E. Class 125, OS&Y, Bronze-Mounted, Cast-Iron Gate Valves: Cast-iron body with bronze trim, rising stem, and solid-wedge disc.

F. Class 125, NRS, All-Iron, Cast-Iron Gate Valves: Cast-iron body with cast-iron trim, nonrising stem, and solid-wedge disc.

G. Class 125, OS&Y, All-Iron, Cast-Iron Gate Valves: Cast-iron body with cast-iron trim, rising stem, and solid-wedge disc.

2.10 CAST-IRON PLUG VALVES

A. Manufacturers:

1. Lubricated-Type, Cast-Iron Plug Valves:

(a) Milliken Valve Co., Inc.

(b) Nordstrom Valves, Inc.

(c) Olson Technologies; Homestead Div.

(d) Walworth Co.

2. Nonlubricated-Type, Cast-Iron Plug Valves:

(a) General Signal; DeZurik Unit.

(b) Grinnell Corporation.

(c) Mueller Flow Technologies.

(d) Xomox Corporation.

B. Cast-Iron Plug Valves, General: MSS SP-78.

C. Class 125 or 150, lubricated-type, cast-iron plug valves.

D. Class 125 or 150, nonlubricated-type, cast-iron plug valves.

2.11 RESILIENT-SEATED, CAST-IRON, ECCENTRIC PLUG VALVES

A. Available Manufacturers:

1. General Signal; DeZurik Unit.

2. Milliken Valve Company.

3. Olson Technologies; Homestead Div.

4. Pratt, Henry Company.

5. Val-Matic Valve & Mfg. Corp.

B. Resilient-Seated, Cast-Iron, Eccentric Plug Valves, NPS 2-1/2 (DN 65) and Smaller: Design similar to MSS SP-108, and rated for 175-psig (1207-kPa) minimum CWP.

1. Resilient Seating Material: Suitable for potable-water service, unless otherwise indicated.

C. Resilient-Seated, Cast-Iron, Eccentric Plug Valves, NPS 3 (DN 80) and Larger: MSS SP-108, and rated for 175-psig (1207-kPa) minimum CWP.

1. Resilient Seating Material: Suitable for potable-water service, unless otherwise indicated.

2.12 CHAINWHEEL ACTUATORS

A. Available Manufacturers:

1. Babbitt Steam Specialty Co.

2. Roto Hammer Industries, Inc.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Sprocket Rim with Chain Guides: Ductile iron Cast iron Aluminum Bronze, of type and size required for valve. Include zinc coating.

2. Brackets: Type, number, size, and fasteners required to mount actuator on valve.

3. Chain: Hot-dip, galvanized steel Brass Stainless steel, of size required to fit sprocket rim.

2.13 BACKFLOW PREVENTERS

A. Approvals: Backflow preventors shall comply with the requirements of all applicable codes and standards in accordance with federal, state, city, and local authorities, including all certificates and approvals, as applicable.

B. Manufacturers:

1. Ames Co., Inc.

2. Cla-Val Co.

3. CMB Industries, Inc.; Febco Backflow Preventers.

4. Conbraco Industries, Inc.

5. Mueller Co.; Hersey Meters Div.

6. Watts Industries, Inc.; Water Products Div.

7. Zurn Industries, Inc.; Wilkins Div.

C. General: ASSE standard, backflow preventers.

1. NPS 2 (DN 50) and Smaller: Bronze body with threaded ends.

2. NPS 2-1/2 (DN 65) and Larger: Bronze, cast-iron, steel, or stainless-steel body with flanged ends.

(a) Interior Lining: AWWA C550 or FDA-approved, epoxy coating for backflow preventers having cast-iron or steel body.

3. Interior Components: Corrosion-resistant materials.

4. Exterior Finish: Polished chrome plate if used in chrome-plated piping system.

5. Strainer: On inlet, if indicated.

D. Pipe-Applied, Atmospheric-Type Vacuum Breakers: ASSE 1001, with floating disc and atmospheric vent.

E. Hose-Connection Vacuum Breakers: ASSE 1011, nickel plated, with nonremovable and manual drain features, and ASME B1.20.7, garden-hose threads on outlet. Units attached to rough-bronze-finish hose connections may be rough bronze.

F. Intermediate Atmospheric-Vent Backflow Preventers: ASSE 1012, suitable for continuous pressure application. Include inlet screen and two independent check valves with intermediate atmospheric vent.

G. Reduced-Pressure-Principle Backflow Preventers: ASSE 1013, suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and strainer on inlet; test cocks; and pressure-differential relief valve with ASME A112.1.2 air-gap fitting located between two positive-seating check valves.

1. Pressure Loss: 12 psig (83 kPa) maximum, through middle 1/3 of flow range.

H. Double-Check Backflow Prevention Assemblies: ASSE 1015, suitable for continuous pressure application. Include shutoff valves on inlet and outlet, and strainer on inlet; test cocks; and two positive-seating check valves.

1. Pressure Loss: 5 psig (35 kPa) maximum, through middle 1/3 of flow range.

I. Antisiphon-Pressure-Type Vacuum Breakers: ASSE 1020, suitable for continuous pressure application. Include shutoff valves, spring-loaded check valve, spring-loaded floating disc, test cocks, and atmospheric vent.

1. Pressure Loss: 5 psig (35 kPa) maximum, through middle 1/3 of flow range.

J. Dual-Check-Valve-Type Backflow Preventers: ASSE 1024, suitable for continuous pressure application. Include union inlet and two independent check valves.

K. Dual-Check-Valve-Type Backflow Preventers: ASSE 1032, suitable for continuous pressure application for carbonated beverage dispensers. Include stainless-steel body; primary and secondary checks; ball check; intermediate atmospheric-vent port for relieving carbon dioxide; and threaded ends, NPS 3/8 (DN 10).

L. Laboratory Faucet Vacuum Breakers: ASSE 1035, suitable for continuous pressure application and chrome plated; consisting of primary and secondary checks; intermediate vacuum breaker; and threaded ends, NPS 1/4 or NPS 3/8 (DN 8 or DN 10) as required.

M. Reduced-Pressure Detector Assembly Backflow Preventers: ASSE 1047, FM approved or UL listed, and suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and strainer on inlet. Include test cocks; pressure-differential relief valve with ASME A112.1.2 air-gap fitting located between two positive-seating check valves; and bypass with displacement-type water meter, valves, and reduced-pressure backflow preventer.

1. Pressure Loss: 12 psig (83 kPa) maximum, through middle 1/3 of flow range.

N. Double-Check Detector Assembly Backflow Preventers: ASSE 1048, FM approved or UL listed, and suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and strainer on inlet. Include test cocks; two positive-seating check valves; and bypass with displacement-type water meter, valves, and double-check backflow preventer.

1. Pressure Loss: 5 psig (35 kPa) maximum, through middle 1/3 of flow range.

O. Hose-Connection Backflow Preventers: ASSE 1052, suitable for at least 3-gpm (0.19-L/s) flow and applications with up to 10-foot head of water (30-kPa) back pressure. Include two check valves; intermediate atmospheric vent; and nonremovable, ASME B1.20.7, garden-hose threads on outlet.

P. Back-Siphonage Backflow Vacuum Breakers: ASSE 1056, suitable for continuous pressure and backflow applications. Include shutoff valves, check valve, test cocks, and vacuum vent.

2.14 WATER REGULATORS (PRESSURE REDUCING VALVES)

A. Manufacturers:

1. Cla-Val Co.

2. Watts Industries, Inc.; Water Products Div.

3. Zurn Industries, Inc.; Wilkins Div.

B. General: ASSE 1003, water regulators, rated for initial working pressure of 150 psig (1035 kPa) minimum. Include integral factory-installed or separate field-installed, Y-pattern strainer.

1. NPS 2 (DN 50) and Smaller: Bronze body with threaded ends.

(a) General-Duty Service: Single-seated, direct operated, unless otherwise indicated.

(b) Booster Heater Water Supply: Single-seated, direct operated with integral bypass.

2. NPS 2-1/2 (DN 65) and Larger: Bronze or cast-iron body with flanged ends. Include AWWA C550 or FDA-approved, interior epoxy coating for regulators with cast-iron body.

(a) Type: Single-seated, direct operated.

(b) Type: Pilot-operated, single- or double-seated, cast-iron-body main valve, with bronze-body pilot valve.

3. Interior Components: Corrosion-resistant materials.

4. Exterior Finish: Polished chrome plate if used in chrome-plated piping system.

5. Standpipe Valves

a. See standpipe equipment under other sections of specifications.

2.15 BALANCING VALVES

A. Calibrated Balancing Valves: Adjustable, with two readout ports and memory setting indicator. Include manufacturer's standard hoses, fittings, valves, differential pressure meter, and carrying case.

1. Manufacturers:

(a) Amtrol, Inc.

(b) Armstrong Pumps, Inc.

(c) ITT Industries; Bell & Gossett Div.

(d) Taco, Inc.

(e) Tour & Andersson, Inc. (Victaulic)

(f) Watts Industries, Inc.; Water Products Div.

2. NPS 2 (DN 50) and Smaller: Bronze body with brass ball, adjustment knob, calibrated nameplate, and threaded or solder-joint ends.

3. NPS 2 (DN 50) and Smaller: Bronze, Y-pattern body with adjustment knob and threaded ends.

4. NPS 2-1/2 (DN 65) and Larger: Cast-iron, Y-pattern body with bronze disc and flanged or grooved ends.

2.16 DRAIN VALVES

A. Install low points and base of all risers.

B. Hose-End Drain Valves: MSS SP-110, NPS 3/4 (DN 20) ball valve, rated for 400-psig (2760-kPa) minimum CWP. Include two-piece, copper-alloy body with standard port, chrome-plated brass ball, replaceable seats and seals, blowout-proof stem, and vinyl-covered steel handle.

1. Inlet: Threaded or solder joint.

2. Outlet: Short-threaded nipple with ASME B1.20.7, garden-hose threads and cap.

C. Hose-End Drain Valve: MSS SP-80, gate valve, Class 125, ASTM B 62 bronze body, with NPS 3/4 (DN 20) threaded or solder-joint inlet and ASME B1.20.7, garden-hose threads on outlet and cap. Hose bibbs are prohibited for this application.

D. Stop-and-Waste Drain Valves: MSS SP-110, ball valve, rated for 200-psig (1380-kPa) minimum CWP or MSS SP-80, Class 125, gate valve; ASTM B 62 bronze body, with NPS 1/8 (DN 6) side drain outlet and cap.

2.17 STRAINERS

A. Strainers: Y-pattern, unless otherwise indicated, and full size of connecting piping. Include ASTM A 666, Type 304, stainless-steel screens with 3/64-inch (1.2-mm) round perforations, unless otherwise indicated.

1. Pressure Rating: 125-psig (860-kPa) minimum steam working pressure, unless otherwise indicated.

2. NPS 2 (DN 50) and Smaller: Bronze body, with female threaded ends.

3. NPS 2-1/2 (DN 65) and Larger: Cast-iron body, with interior AWWA C550 or FDA-approved, epoxy coating and flanged ends.

4. Y-Pattern Strainers: Screwed screen retainer with centered blowdown.

(a) Drain: Hose-end drain valve.

5. T-Pattern Strainers: Malleable-iron or ductile-iron body with grooved ends; access end cap with drain plug and access coupling with rubber gasket.

6. Basket Strainers: Bolted flange or clamp cover, and basket with lift-out handle.

   (a) Type: Simplex with one basket

   (b) Drain: Hose-end drain valve.

B. Drainage Basket Strainers: Non-pressure-rated, cast-iron or coated-steel body; with bolted flange or clamp cover and drain with plug.

1. Basket: Bronze or stainless steel with 1/8- or 3/16-inch- (3.2- or 4.8-mm-) diameter holes and lift-out handle.

2. Female threaded ends for NPS 2 (DN 50) and smaller, and flanged ends for NPS 2-1/2 (DN 65) and larger.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.

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

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE APPLICATIONS

A. Refer to valve schedule use the following:

1. Shutoff Service: Ball or gate valves.
2. Throttling Service: ball, butterfly, or.
3. Pump Discharge: Spring-loaded check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.

C. Domestic Water Piping: Use the following types of valves:

1. Angle Valves, NPS 2 (DN 50) and Smaller: Type 2, Class 125 bronze.

2. Angle Valves, NPS 2-1/2 (DN 65) and Larger: Type II, Class 125, cast iron.

3. Ball Valves, NPS 2 (DN 50) and Smaller: Three-piece, 400-psig (2760-kPa) CWP rating, copper alloy.

4. Ball Valves, NPS 2-1/2 (DN 65) and Larger: Class 150 ferrous alloy.

5. Butterfly Valves, NPS 2-1/2 (DN 65) and Larger:Flanged, 150-psig CWP rating, ferrous alloy, with EPDM liner.

6. Swing Check Valves, NPS 2 (DN 50) and Smaller: Type 4, Class 125, bronze.

7. Swing Check Valves, NPS 2-1/2 (DN 65) and Larger: Type II, Class 125, gray iron.

8. Gate Valves, NPS 2 (DN 50) and Smaller: Type 1, Class 125 bronze.

9. Gate Valves, NPS 2-1/2 (DN 65) and Larger: Type I, Class 125, NRS, bronze-mounted cast iron.

10. Globe Valves, NPS 2 (DN 50) and Smaller: Type 2, Class 125, bronze.

11. Globe Valves, NPS 2-1/2 (DN 65) and Larger: Type I, Class 125, bronze-mounted cast iron.

12. Plug Valves, NPS 2 (DN 50) and Larger: Class 125 or 150, lubricated-type, cast iron.

13. Resilient-Seated, Eccentric Plug Valves, NPS 3 (DN 80) and Larger: 175-psig (1207-kPa) CWP rating, cast iron.

D. Select valves, except wafer and flangeless types, with the following end connections:

1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Solder-joint or threaded ends, except provide valves with threaded ends for [condenser water,] heating hot water, steam, and steam condensate services.

2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged.

3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.

4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.

5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends.

6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

3.3 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves in horizontal piping with stem at or above center of pipe.

E. Install valves in position to allow full stem movement.

F. Install chainwheel operators on valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor elevation.

G. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.

H. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.

2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.

3. Do not install bypass piping around backflow preventers.

4. Install backflow preventers between 18" and 60" above finished floor.

I. Install pressure regulators with inlet and outlet shutoff valves, inlet strainers and balance valve bypass. Install pressure gages on inlet and outlet.

J. Install strainers on supply side of each control valve, pressure regulator, and solenoid valve.

3.4 JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Plumbing Materials and Methods" for basic piping joint construction.

B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

C. All welded joints for steel pipe shall be of the open V-butt type following approved welding procedures for metallic arc or oxy-acetylene carbon steel welded pipe joints. Pipe shall be millbeveled or machine beveled by this Trade. All scale and oxide must be removed with hammer, chisel or file, and the bevel left smooth and clean.

3.5 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

END OF SECTION 15110

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes pipe expansion loops for mechanical piping systems, and the following:

1. Pipe bends and loops.

2. Guides and anchors.

1.3 PERFORMANCE REQUIREMENTS

A. Compatibility: Products suitable for piping system fluids, materials, working pressures, and temperatures.

B. Capability: Absorb 200 percent of maximum piping expansion between anchors.

1.4 SUBMITTALS

A. Product Date: For each type of expansion fitting indicated.

1.5 QUALITY ASSURANCE

A. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for expansion fittings and loops by a qualified professional engineer.

1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of expansion fitting and loops that are similar to those indicated for this Project in material, design, and extent.

B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, “Welding and Brazing Qualifications.”

PART 2 - PRODUCTS

2.1 GUIDES

A. Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.

2.2 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A36/A36M.

B. Bolts and Nuts: ASME B18.10 or ASTM A183, steel, hex head.

C. Washers: ASTM F 844, steel, plain, flat washers.

D. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.

1. Stud: Threaded, zinc-coated carbon steel.

2. Expansion Plug: zinc-coated steel.

3. Washer and Nut: zinc-coated steel.

E. Chemical Fasteners: Insert-type stud bonding system and for use with hardened Portland cement concrete, and tension and shear capacities appropriate for application.

1. Bonding Material: ASTM C 881, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.

2. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.

3. Washer and Nut: zinc-coated steel.

F. Concrete: Portland cement mix, 20.7 MPa minimum. Refer to Division 3 Section “Cast-in-Place Concrete” for formwork, reinforcement, and concrete.

G. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged non-shrink and nonmetallic grout; suitable for interior and exterior applications.

1. Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement grout.

2. Properties: Non-staining, non-corrosive, and non-gaseous.

3. Design Mix: 34.5-MPa, 28-day compressive strength.

PART 3 - EXECUTION

3.1 PIPE BEND AND LOOP INSTALLATION

A. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Attach pipe bends and loops to anchors.

1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, “Welding and Brazing Qualifications.”

2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer’s written instructions.

3.3 SWING CONNECTIONS

A. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

3.4 GUIDE INSTALLATION

A. Expansion loops or flexible pipe connections shall be guided to confine the degree of pipe movement.

B. Attach guides to pipe and secure to building structure.

3.5 ANCHOR INSTALLATION

A. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.

D. Install pipe anchors according to expansion fitting manufacturer’s written instructions if expansion fitting are indicated.

E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

3.6 PAINTING

A. Touching Up - Clean field welds and abraded areas of shop paint. Pain exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 0.05 mm.

B. Galvanized Surfaces - Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 15121

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes domestic water piping and water meters inside the building.

B. Water meters shall be as required by the utility company furnished and installed by the Contractor.

C. Related Sections include the following:

1. Division 2 Section "Water Distribution" for water-service piping and water meters outside the building from source to the point where water-service piping enters the building.
2. Division 15 Section "Plumbing - Meters and Gages" for thermometers, pressure gages, and fittings.
3. Division 15 Section "Plumbing Specialties" for water distribution piping specialties.

1.3 DEFINITIONS

A. CPVC: Chlorinated polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing domestic water piping systems with 125 psig (860 kPa), unless otherwise indicated.

1.5 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings and water meters.

B. Water Samples: Specified in Part 3 "Cleaning" Article.

C. Field quality-control test reports.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for potable domestic water piping and components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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

2.2 PIPING MATERIALS

A. Refer to Part 3 "Pipe and Fitting Applications" Article for applications of pipe, tube, fitting, and joining materials.

B. Transition Couplings for Aboveground Pressure Piping: Coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A, Schedule 40, galvanized. Include ends matching joining method.

1. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
2. Malleable-Iron Unions: ASME B16.39, Class 150, hexagonal-stock body, with ball-and-socket, metal-to-metal, bronze seating surface and female threaded ends.
3. Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, standard pattern.
4. Cast-Iron Flanges: ASME B16.1, Class 125.
5. Cast-Iron, Flanged Fittings: ASME B16.1, Class 125, galvanized.

2.4 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Types K and L (ASTM B 88M, Types A and B), water tube, drawn temper.

1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought- copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Furnish Class 300 flanges if required to match piping.
3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
4. Copper, Grooved-End Fittings: ASTM B 75 (ASTM B 75M) copper tube or ASTM B 584 bronze castings.

2.5 VALVES

A. Bronze and cast-iron, general-duty valves are specified in Division 15 Section "Valves."

B. Balancing and drain valves are specified in Division 15 Section "Plumbing Specialties."

2.6 WATER METERS

A. Displacement-Type Water Meters NPS 2 (DN 50) and Smaller: AWWA C700, nutating-disc totalization meter with bronze case and 150-psig (1035-kPa) minimum working-pressure rating; with registration in gallons (liters) or cubic feet (cubic meters) as required by utility; and with threaded end connections.

1. Manufacturers:

    a. ABB.
    b. Badger Meter, Inc.
    c. Carlon Meter Company Inc.
    d. Invensys North American Water.
    e. Mueller Company.
    f. Schlumberger Limited; Water Div.
    g. Venture Measurement.

B. Turbine-Type Water Meters: AWWA C701, totalization meter with [150-psig (1035-kPa)] minimum working-pressure rating; with registration in gallons (liters) or cubic feet (cubic meters) as required by utility; and with the following end connections:

1. NPS 2 (DN 50) and Smaller: Threaded.
2. NPS 2-1/2 (DN 65) and Larger: Flanged.
3. Manufacturers:

    a. ABB.
    b. Badger Meter, Inc.
    c. Hays Fluid Controls.
    d. Invensys North American Water.
    e. Master Meter, Inc.
    f. McCrometer.
    g. Mueller Company.
    h. Schlumberger Limited; Water Div.
    i. SeaMetrics Inc.
    j. Venture Measurement.

C. Compound-Type Water Meters NPS 3 (DN 80) and Larger: AWWA C702, totalization meter with integral main-line and bypass meters, bronze case, and 150-psig (1035-kPa) minimum working-pressure rating; with registration in gallons (liters) or cubic feet (cubic meters) as required by utility; and with flanged end connections.

1. Manufacturers:

a. ABB.
b. Badger Meter, Inc.
c. Invensys North American Water.
d. Master Meter, Inc.
e. Mueller Company.
f. Schlumberger Limited; Water Div.

2. Proportional, Detector-Type Water Meters: With meter on bypass.

a. Bypass Meter: AWWA C701, turbine type with bronze case; size not less than one-half nominal size of main-line meter.

3. Turbine-Type Water Meters: With strainer and with meter on bypass.

a. Strainer: Full size, matching water meter.
b. Bypass Meter: AWWA C701, turbine type with bronze case; not less than NPS 2 (DN 50).

D. Remote Registration System: Direct-reading type complying with AWWA C706; modified with signal transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility.

E. Remote Registration System: Encoder-type complying with AWWA C707; modified with signal transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Excavating, trenching, and backfilling are specified in Division 2 Section "Earthwork."

3.2 PIPE AND FITTING APPLICATIONS

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.

B. Flanges may be used on aboveground piping, unless otherwise indicated.

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Under-Building-Slab, Water-Service Piping on Service Side of Water Meter: Refer to Division 2 Section "Water Distribution."

E. Domestic Water Piping on Service Side of Water Meter inside the Building: Use any of the following piping materials for each size range:

1. NPS 4 to NPS 12 (DN 100 to DN 300): Steel pipe; gray-iron, threaded fittings; and threaded joints.
2. NPS 4 to NPS 12 (DN 100 to DN 300): Steel pipe with grooved ends; steel-piping, grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
3. NPS 4 to NPS 6 (DN 100 to DN 150): Hard copper tube, [Type K (Type A)] [Type L (Type B)]; copper pressure fittings; and soldered joints.
4. NPS 4 to NPS 6 (DN 100 to DN 150): Hard copper tube, [Type K (Type A)] [Type L (Type B)] with grooved ends; copper grooved-end fittings; grooved-end-tube couplings; and grooved joints.

F. Under-Building-Slab, Domestic Water Piping on House Side of Water Meter, NPS 4 (DN 100) and Smaller: [Soft] [Hard] copper tube, Type K (Type A); copper pressure fittings; and soldered joints.

G. Aboveground Domestic Water Piping: See schedule on the drawings:

3.3 VALVE APPLICATIONS

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use bronze ball or gate valves for piping NPS 2 (DN 50) and smaller. Use cast-iron butterfly or gate valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
2. Throttling Duty: Use bronze ball or globe valves for piping NPS 2 (DN 50) and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
3. Hot-Water-Piping, Balancing Duty: Calibrated or Memory-stop balancing valves.
4. Drain Duty: Hose-end drain valves.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use butterfly or gate valves for piping NPS 2-1/2 (DN 65) and larger.

C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping.

1. Install hose-end drain valves at low points in water mains, risers, and branches.
2. Install stop-and-waste drain valves where indicated.

D. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Calibrated balancing valves are specified in Division 15 Section "Plumbing Specialties."

3.4 PIPING INSTALLATION

A. Basic piping installation requirements are specified in Division 15 Section "Basic Mechanical Materials and Methods."

B. Install under-building-slab copper tubing according to CDA's "Copper Tube Handbook."

C. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall or floor. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 15 Section "Basic Plumbing Materials and Methods."

D. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Wall penetration systems are specified in Division 15 Section "Basic Plumbing Materials and Methods."

E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Pressure gages are specified in Division 15 Section "Plumbing - Meters and Gages," and drain valves and strainers are specified in Division 15 Section "Plumbing Specialties."

F. Install water-pressure regulators downstream from shutoff valves. Water-pressure regulators are specified in Division 15 Section "Plumbing Specialties."

G. Install domestic water piping level and plumb.

H. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

3.5 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 15 Section "Basic Plumbing Materials and Methods."

B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

C. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

3.6 WATER METER INSTALLATION

A. Rough-in domestic water piping and install water meters according to utility company's requirements.

B. Coordinate water meter installation with utility company.

C. Install water meters according to AWWA M6 and utility's requirements.

1. Install displacement-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.
2. Install turbine-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.
3. Install compound-type water meters with shutoff valves on water-meter inlet and outlet and on valved bypass around meter. Support meters, valves, and piping on brick or concrete piers.
4. Install fire-service water meters with shutoff valves on water-meter inlet and outlet and on full-size valved bypass around meter. Support meter, valves, and piping on brick or concrete piers.
5. Install remote registration system according to standards of utility and of authorities having jurisdiction.

3.7 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Division 15 Section "Plumbing - Vibration and Seismic Controls."

B. Pipe hanger and support devices are specified in Division 15 Section "Plumbing - Hangers and Supports." Install the following:

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

    a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet (30 m): MSS Type 49, spring cushion rolls, if indicated.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Division 15 Section "Hangers and Supports."

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced 1 size for double-rod hangers, to a minimum of 3/8 inch (10 mm).

F. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32) and Smaller: 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
3. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
5. NPS 3 and NPS 3-1/2 (DN 80 and DN 90): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
7. NPS 6 (DN 150): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.
8. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.

G. Install supports for vertical steel piping every 15 feet (4.5 m).

H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
5. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
6. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
7. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

I. Install supports for vertical copper tubing every 10 feet (3 m).

J. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.8 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment and machines to allow service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve, and extend and connect to the following:

1. Booster Pumps: Cold-water suction and discharge piping.
2. Water Heaters: Cold-water supply and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.

3. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 15 Section "Plumbing Fixtures."
4. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 (DN 65) and larger.

3.9 FIELD QUALITY CONTROL

A. Inspect domestic water piping as follows:

1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
2. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

    a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
    b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

3. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

B. Test domestic water piping as follows:

1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
4. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.10 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.

3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

   a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
   b. Adjust calibrated balancing valves to flows indicated.

5. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

A. Clean and disinfect potable and/or non-potable domestic water piping as follows:

   1. Purge new piping and parts of existing domestic water piping that have been altered, extended, or repaired before using.
   2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction or, if methods are not prescribed, procedures described in either AWWA C651 or AWWA C652 or as described below:

      a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
      b. Fill and isolate system according to either of the following:

         1) Fill system or part thereof with water/chlorine solution with at least 50 ppm (50 mg/L) of chlorine. Isolate with valves and allow to stand for 24 hours.
         2) Fill system or part thereof with water/chlorine solution with at least 200 ppm (200 mg/L) of chlorine. Isolate and allow to stand for three hours.

      c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
      d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

B. Prepare and submit reports of purging and disinfecting activities.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

END OF SECTION 15140

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following for soil, waste, and vent piping inside the building:

1. Pipe, tube, and fittings.
2. Special pipe fittings.
3. Encasement for underground metal piping.

B. Related Sections include the following:

1. Division 15 Section "Plumbing - Chemical-Waste Piping" for chemical-waste and vent piping systems.
2. Division 15 Section "Plumbing - Sewage Pumps."

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

C. LLDPE: Linear, low-density polyethylene plastic.

D. NBR: Acrylonitrile-butadiene rubber.

E. PE: Polyethylene plastic.

F. PVC: Polyvinyl chloride plastic.

G. TPE: Thermoplastic elastomer.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:

1. Sanitary, Vent and Storm Drainage Piping: 10-foot head of water (30 kPa)..
2. Sanitary Sewer, Force-Main Piping: 50 psig (345 kPa).

B. Seismic Performance: Sanitary, vent and storm drainage piping and support and installation shall be capable of withstanding the effects of seismic events determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

1.5 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. Shop Drawings:

1. Design Calculations: Signed and sealed by a qualified professional engineer for selecting seismic restraints.

C. Field quality-control inspection and test reports.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency..

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.3 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service class.

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.4 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.

1. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.

   a. Manufacturers:

      1) ANACO.
      2) Clamp-All Corp.
      3) Ideal Div.; Stant Corp.
      4) Mission Rubber Co.
      5) Tyler Pipe; Soil Pipe Div.

2. Heavy-Duty, Shielded, Cast-Iron Couplings: ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve.

   a. Manufacturer:

      1) MG Piping Products Co..

2.5 GALVANIZED STEEL PIPE AND FITTINGS

A. Galvanized Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A or B, Schedule 40, galvanized. Include ends matching joining method.

B. Drainage Fittings: ASME B16.12, galvanized, threaded, cast-iron drainage pattern.

C. Pressure Fittings:

1. Galvanized Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
2. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
3. Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, standard pattern.
4. Cast-Iron Flanges: ASME B16.1, Class 125.

5. Cast-Iron, Flanged Fittings: ASME B16.1, Class 125, galvanized.

2.6 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end, unless grooved or flanged ends are indicated.

1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end, unless grooved or flanged ends are indicated.

1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Gaskets: AWWA C111, rubber.

C. Flanges: ASME 16.1, Class 125, cast iron.

2.7 COPPER TUBE AND FITTINGS

A. Copper Type M (Type C) Tube: ASTM B 306, drainage tube, drawn temper.

1. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

B. Hard Copper Tube: ASTM B 88, Types L and M (ASTM B 88M, Types B and C), water tube, drawn temper.

1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
3. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

2.8 SPECIAL PIPE FITTINGS

A. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers:

a. Dallas Specialty & Mfg. Co.
b. Fernco, Inc.
c. Logan Clay Products Company (The).
d. Mission Rubber Co.

e. NDS, Inc.
f. Plastic Oddities, Inc.

2. Sleeve Materials:

a. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
b. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

B. Shielded Nonpressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers:
a. Cascade Waterworks Mfg. Co.
b. Mission Rubber Co.

C. Rigid, Unshielded, Nonpressure Pipe Couplings: ASTM C 1461, sleeve-type reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturer:
a. ANACO.

D. Pressure Pipe Couplings: AWWA C219 metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.

1. Manufacturers:
a. Cascade Waterworks Mfg. Co.
b. Dresser, Inc.; DMD Div.
c. EBAA Iron Sales, Inc.
d. Ford Meter Box Company, Inc. (The); Pipe Products Div.
e. JCM Industries, Inc.
f. Romac Industries, Inc.
g. Smith-Blair, Inc.
h. Viking Johnson.

2. Center-Sleeve Material: Manufacturer's standard
3. Gasket Material: Natural or synthetic rubber.
4. Metal Component Finish: Corrosion-resistant coating or material.

E. Wall-Penetration Fittings: Compound, ductile-iron coupling fitting with sleeve and flexing sections for up to 20-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.

1. Manufacturer:
a. SIGMA Corp.

2.9 ENCASEMENT FOR UNDERGROUND METAL PIPING

A. Description: ASTM A 674 or AWWA C105, high-density, crosslaminated PE film of 0.004-inch (0.10-mm) minimum thickness.

B. Form: tube.

C. Color Black.

2.10 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.
   1. PVC Socket Fittings: ASTM D2665, socket type, made to ASTM D3311, drain, waste, and vent patterns.

2.11 SPECIAL PIPE FITTINGS

A. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.
   1. Manufacturers:
      a. Dallas Specialty & Mgg. Co.
      b. Fernco, Inc.
      c. Logan Clay Products Company (The).
      d. Mission Rubber co.
      e. NDS, Inc.
      f. Plastic Oddities, Inc.

   2. Sleeve Materials:
      a. For cast-Iron Soil Pipes: ASTM C 564, rubber.
      b. For Plastic Pipes: ASTM F477, elastomeric seal or ASTM D 5926, PVC.
      c. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

B. Shielded Nonpressure pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
   1. Manufacturers:
      a. Cascade Waterworks Mfg. Co.
      b. Mission Rubber Co.

C. Rigid, Unshielded, Nonpressure Pipe Couplings: ASTM C 1461, sleeve-type reducing, or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.

2.12 PIPING APPLICATIONS

A. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

B. Dissimilar Pipe-Material Couplings: Rigid, unshielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD. Underground, sanitary, vent and storm drainage piping NPS 2 (DN 50) and larger shall be any of the following:
   1. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

2.13 JOINT CONSTRUCTION

A. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.

2.14 PROTECTION

A. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 2 Section "Earthwork" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground, sanitary, vent and storm drainage piping NPS 2 (DN 50) and larger shall be the following:

   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless cast-iron soil pipe and fittings heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.
   3. Steel pipe, drainage fittings, and threaded joints.
   4. Copper DWV tube, copper drainage fittings, and soldered joints.
   5. Dissimilar Pipe-Material Couplings: Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

C. Underground, sanitary, vent and storm drainage piping NPS 2 (DN 50) and larger shall be the following:

   1. Service class, cast-iron soil piping; gaskets; and gasketed joints.

2. Dissimilar Pipe-Material Couplings: Shielded nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

D. Aboveground sanitary-sewage force mains [NPS 1-1/2 and NPS 6 (DN 40 and DN 150)] shall be any of the following:

1. Hard copper tube, Type L (Type B); copper pressure fittings; and soldered joints.

2. Galvanized steel pipe, pressure fittings, and threaded joints.

3.3 PIPING INSTALLATION

A. Sanitary sewer piping outside the building is specified in Division 2 Section "Sanitary Sewerage."

B. Basic piping installation requirements are specified in Division 15 Section "Basic Plumbing Materials and Methods."

C. Install seismic restraints on piping. Seismic-restraint devices are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

D. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.

E. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.

F. Install underground, ductile-iron, special pipe fittings according to AWWA C600.

1. Install encasement on piping according to ASTM A 674 or AWWA C105.

G. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 15 Section "Basic Mechanical Materials and Methods."

H. Install wall-penetration fitting at each service pipe penetration through foundation wall. Make installation watertight.

I. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.

J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

K. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

L. Install sanitary, vent and storm drainage piping at the following minimum slopes, unless otherwise indicated:

1. Building Sanitary and Storm Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
2. Horizontal Sanitary and Storm Drainage Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

M. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

N. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

O. Vent piping shall be run in a system of branches and stacks continuously upward to a point of minimum 24" (1800 mm) above the roof.

3.4 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 15 Section "Basic Mechanical Materials and Methods."

B. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

C. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.

D. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

E. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

F. Grooved Joints: Assemble joint with keyed coupling, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 15 Section "Valves."

B. Shutoff Valves: Install shutoff valve on each sewage pump discharge.

1. Install gate or full-port ball valve for piping NPS 2 (DN 50) and smaller.
2. Install gate valve for piping NPS 2-1/2 (DN 65) and larger.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

3.6 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Division 15 Section "Plumbing - Vibration Controls and Seismic Restraints."

B. Pipe hangers and supports are specified in Division 15 Section "Plumbing - Hangers and Supports." Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Install individual, straight, horizontal piping runs according to the following:

    a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Division 15 Section "Plumbing - Hangers and Supports."

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 (DN 150): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
5. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.

G. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).

H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.

2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
3. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
5. NPS 3 (DN 80): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
7. NPS 6 (DN 150): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.
8. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.

I. Install supports for vertical steel piping every 15 feet (4.5 m).

J. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
3. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
4. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
5. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
6. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

K. Install supports for vertical copper tubing every 10 feet (3 m).

L. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 (DN 65) and larger.

D. Connect force-main piping to the following:

1. Waste Pumps: To sewage pump discharge.

3.8 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.

2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary, storm drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg (250 Pa). Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

6. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

2. Cap and subject piping to static-water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.9 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops

END OF SECTION 15150

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Vibration control.

B. Description of Work

1. It is the objective of this specification to provide the necessary design requirements for the control of excessive noise and vibration in buildings due to the operation of machinery or equipment, and/or due to interconnected piping, ductwork or conduit.

2. Provide vibration isolation systems, complete as shown and specified per Contract Documents.

3. The work of this section includes, but is not limited to, the following:

(a) Vibration isolation elements for piping and equipment;

(b) Equipment isolation bases;

(c) Piping flexible connections;

1.2 RELATED DOCUMENTS

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

B. Section 15010 - Basic Mechanical Requirements

C. Section 15050 - Basic Materials, Methods and Requirements (Mechanical).

D. This section is a part of each Division 15000 Section.

1.3 REFERENCES

A. ASHRAE.

1.4 QUALITY ASSURANCE

A. Applicator: Products provided by company specializing in vibration isolation with ten years minimum experience.

B. All vibration isolation devices shall be the product of a single manufacturer. Products of other manufacturers are acceptable, provided that their systems comply with the design intent for system performance, static deflection and structural design of the base manufacturer.

C. The following are approved manufacturers, provided their systems strictly comply with the design intent for performance, deflection and structural capacity of this specification.

1.	Mason Industries, Inc.	Hauppauge, NY
2.	Vibration Mountings & Controls	Bloomingdale, NJ
3.	Kinetics Company,	Dunlin, OH
4.	Korfund Dynamics Corp.,	Bloomingdale, NJ
5.	Vibration Eliminator Co., Inc.,	Long Island City, NY
6.	Amber Booth,	Houston, TX

D. Vibration isolation firms having a minimum of ten (10) years experience in designing and installing vibration isolation systems shall be qualified to provide the materials and installation required by this section. Project listings shall be provided including geographical location and a reference contact.

1.5 SUBMITTALS

A. Submit product data under provisions of Section 01300.

B. Include product description, list of materials for each service, and locations.

C. Submit manufacturer's installation instructions under provisions of Section 01300.

D. Vibration isolation equipment submittal drawings shall include the following information:

1. Isolation mounting deflections.

2. Spring diameters, compressed spring heights at rated load; solid spring heights, where steel spring isolation mountings are used.

3. Equipment operating speed.

E. In addition to the requirements on Mechanical General Provisions, the submittal material shall include copies of descriptive data for all products and materials including, but not limited to, the following:

1. Descriptive Data:

    (a) Catalog cuts and data sheets on specific vibration isolators to be utilized showing compliance with the specifications.

    (b) An itemized list showing the items of equipment or piping to be isolated, the isolator type and model number selected, isolator loading and deflection.

2. Shop Drawings:

    (a) Drawings showing equipment base constructions for each machine, including dimensions, structural member sizes and support point locations.

    (b) Drawings showing methods of suspension, support guides for piping and ductwork.

    (c) Drawings showing methods for isolation of pipes and ductwork piercing walls and slabs.

    (d) Concrete and steel details for bases, including anchor bolt locations.

PART 2 - PRODUCTS

2.1 FLOOR MOUNTING OF CENTRIFUGAL FANS AND TUBULAR ARRANGEMENT ONE FANS - MOUNTING TYPE I

A. Each such fan and driving motor shall be mounted on an integral one piece structural base, reinforced as necessary to prevent flexure of the base at start up and during operation of the fan. The unitized structural base for the fan and motor shall include motor slide rails. The structural steel frame shall be drilled and tapped to receive the fan and motor so that the frame shall act as a template. Provide vertical limit stops suitable for applicable wind loads where exposed.

B. The structural steel integral base shall be supported on steel spring mountings. These mountings shall be positioned in accordance with the weight distribution to ensure adequate deflection and vibration isolation. Housing or snubbing devices shall not be used to contain the isolation springs.

C. Isolator types shall be one of the following or as approved:

Type SLF	-	M.I.I.
Type OSK	-	V.E.C.
Type AN	-	V.M.C.I.

2.2 FLOOR MOUNTING OF CENTRIFUGAL FANS - MOUNTING TYPE II

A. Each such fan and motor shall be mounted on a reinforced spring supported concrete foundation. The foundation shall be poured within structural perimeter frame set on roofing paper. The structural perimeter frame shall be supplied by the vibration isolation vendor and shall incorporate equipment anchor bolt templates and mounting brackets for each base spring support. Spring supports shall be located under the brackets and shall incorporate a neoprene acoustical pad and leveling adjustment to raise the entire isolation base 1 inch above the foundation pad.

B. Concrete inertia base thickness shall be in accordance with the following schedule:

Motor Size	Minimum Inertia Block Thickness Required
Up to 50 HP	8"
60 to 75 HP	10"
100 HP & Greater	12"

C. Mounting assemblies shall be one of the following or as approved:

Type KSL	-	M.I.I.
Type AWPF	-	V.M.C.I.
Type SN-OSK	-	V.E.C.

2.3 FLOOR MOUNTING OF CENTRIFUGAL FANS - TYPE III

A. This equipment shall be mounted exactly as described for TYPE I except that mountings shall be neoprene-in-shear and one of the following or as approved:

Type ND	-	M.I.I.
Type RD	-	V.M.C.I.
Type 368SD	-	V.E.C.

2.4 MOUNTING OF PACKAGED AIR HANDLING UNITS, TUBULAR ARRANGEMENT 9 FANS, AND BELTED VENT SETS - MOUNTING TYPE IV

A. Each such equipment shall be mounted on neoprene-in-shear isolators. Mountings shall be one of the following or as approved:

Type ND	-	M.I.I.
Type RD	-	V.M.C.I.
Type 368SD	-	V.E.C.

2.5 MOUNTING OF FLOOR MOUNTED PACKAGED AIR HANDLING UNITS, DX UNITS AND COMPUTER ROOM AC UNITS - MOUNTING TYPE V

A. This equipment shall be mounted directly on stable bare steel spring isolators, except that where the units to be mounted are furnished with internal structural frames and external lugs (both of suitable strength and rigidity), or without any severe overhangs, no additional structural frame need be furnished and installed beneath the unit except minimum 4" housekeeping pad or as required for proper condensate drain. In any event, the motor shall be integrally mounted to the unit and shall be mounted on slide rails. Mounting types shall be as described for TYPE I.

B. Minimum static deflection shall be 1". See schedule.

2.6 MOUNTING OF CEILING SUPPORTED PACKAGED AIR HANDLING UNITS, TUBULAR ARRANGEMENT 9 FANS, & BELTED VENT SETS - MOUNTING TYPE VI

A. All such units shall be hung by means of vibration isolator hangers consisting of a steel housing or retainer incorporating a steel spring and neoprene mounting.

B. If the equipment to be mounted is not furnished with integral structural frames and external mounting lugs (both of suitable strength and rigidity), approved structural sub-base shall be installed in the field which shall support the equipment to be hung and to which shall be attached to the hangers.

C. Isolators shall be one of the following or as approved:

Type 30N	-	M.I.I.
Type 30	-	V.M.C.I.
Type SNRC-4	-	V.E.C.

D. Diagonal hanger rod isolators shall be provided as required to limit horizontal motion to 1/4 inch maximum under fan operating conditions.

2.7 MOUNTING OF CEILING SUPPORTED PACKAGED AIR HANDLING UNITS, TUBULAR ARRANGEMENT 9 FANS AND BELTED VENT SETS - MOUNTING TYPE VII

A. This equipment shall be mounted exactly as described for TYPE VI except that mounting shall be one of the following, or as approved:

Type HD	-	M.I.I.
Type RHD	-	V.M.C.I.
Type CD	-	V.E.C.

B. Diagonal hanger rod isolators shall be provided as required to limit horizontal motion to 1/4 inch maximum under fan operating conditions.

2.8 MOUNTING OF CENTRIFUGAL PUMPS AND FLOOR-MOUNTED IN-LINE PUMPS - (GREATER THAN 3 HP)

A. Each pump with its driving motor shall be bolted and grouted to a spring supported concrete inertia base reinforced as required.

B. Each concrete base (rectangular or "T" shape) for horizontally split pumps shall include supports and base elbows for the suction and discharge connections. Base elbows shall be bolted and grouted to the concrete foundation.

C. Concrete inertia base thickness shall be in accordance with the following schedule:

Motor Size	Minimum Inertia Block Thickness Required
5 HP to 20 HP	6"

20 HP to 60 HP	8"
75 HP to 100 HP	10"
Greater than 100 HP	12"

D. The spring supported concrete inertia foundation shall be poured within structural perimeter frame (reinforced as necessary) of the required thickness indicated in the above schedule. The structural perimeter frame shall be equipped with height saving brackets and stable bare spring isolators having spring diameters no less than 0.8 of the compressed height of the spring at rated load. The mountings shall provide minimum static deflections as indicated on the schedule. The structural perimeter frame, mounting templates, saving brackets and spring system shall be provided as an assembly by the vibration control vendor.

E. Mounting assemblies shall be one of the following or as approved:

Type KSL	-	M.I.I.
Type AWPF	-	V.M.C.I.
Type SN-OSK	-	V.E.C.

2.9 MOUNTING OF CENTRIFUGAL PUMPS (3 HP or less)

A. Pumps 3 HP or less shall be bolted and grouted to rubber-inshear supported reinforced concrete inertia blocks that are a minimum of 6 inches thick. Rubber-in-shear isolators shall provide a minimum static deflection of 3/8 inch and shall be protected against corrosion. Mountings shall be as described for TYPE IV.

2.10 MOUNTING OF HUNG IN-LINE MOUNTED CENTRIFUGAL PUMPS: (GREATER THAN 5HP)

A. Provide hanger at adjacent pipe:

Type PC-30	-	M.I.I.
Type VSHL	-	V.M.C.I.

2.11 MOUNTING OF REFRIGERATION MACHINES AND BOILERS

A. Each machine (cooler-condenser drive-compressor) and boilers shall be resiliently supported on steel spring isolation mountings. The motor-compressor assembly shall be provided with a rigid steel structural base designed to withstand operating forces of the machine. Base shall be furnished as an integral part of the machine by the manufacturer.

B. Spring mountings shall incorporate unrestrained stable springs with built-in leveling device and resilient vertical limit stops to prevent spring elongation MORE THAN 1/8" when partial load is removed. The mountings shall also be capable of providing rigid anchor during erection of machine so that is can be erected at a fixed elevation. After equipment installation is complete and filled with water, the mountings are to be adjusted in accordance with the manufacturer's installation procedures.

C. Spring mountings shall provide a minimum of two inch static deflection for refrigeration machines and a minimum of one inch for boilers and shall have two layers of acoustical neoprene base pads separated by 16 g. sheet metal. Mountings shall be one of the following or as approved:

Type SLR	-	M.I.I.
Type AWR	-	V.M.C.I.
Type WSCL	-	K.D.C.
Type KW	-	V.E.C.

2.12 PIPING GUIDES

A. Type ADA Mason Industries or as approved.

2.13 ACOUSTICAL ANCHORS

A. Type VPA Mason industries or as approved.

2.14 PIPE SUPPORTS WITHIN SHAFTS

A.

Type W	-	MII
Shearflex	-	VMCI
Type 200N	-	VEC

2.15 PIPING SUPPORTS

A. All water piping hanger rod isolators shall be one of the following or as approved:

Type PC30	-	M.I.I.
Type VSHL	-	V.M.C.I.
Type TK	-	V.E.C.
Type VXPM	-	K.D.C.

B. Floor supported water piping shall be mounted on one of the following or as approved:

Type SLR	-	M.I.I.
Type AWR	-	V.M.C.I.
Type KW	-	V.E.C.

C. Floor mounted strainer and storage tank shall be mounted on one of the following or as approved:

Type SLR	-	M.I.I.
Type AWR	-	V.M.C.I.
Type KW	-	V.E.C.

PART 3 - EXECUTION

3.1 GENERAL

A. All equipment, piping, etc. shall be mounted on or suspended from approved foundations and supports, all as specified herein, or as shown on the drawings.

B. All concrete foundations and supports (and required reinforcing and forms) will be furnished and installed by another trade. However, this trade shall furnish shop drawings showing adequate concrete reinforcing steel details and templates for all concrete foundations and supports, and all required hanger bolts and other appurtenances necessary for the proper installation of his equipment. Although another trade will complete all concrete work, all such work shall be shown in detail on the shop drawings, prepared by this trade which drawings shall be submitted showing the complete details of all foundations including necessary concrete and steel work, vibration isolation devices, etc.

C. All floor-mounted equipment shall be erected on minimum 4" high concrete pads over the complete floor area of the equipment, unless specified to the contrary herein. Wherever hereinafter vibration eliminating devices and/or concrete inertia blocks are specified, these items shall, in all cases, be in turn mounted upon 4" high concrete pads unless specified to the contrary herein.

D. The vibration isolation systems shall be guaranteed to have the deflection indicated on the schedule on the drawings. Mounting sizes shall be determined by the mounting manufacturer, and the sizes shall be installed in accordance with the manufacturer's instructions.

E. The installed vibration isolation system for each floor or ceiling supported equipment shall have a maximum lateral motion under equipment start-up or shut down conditions of 1/4 inch. Motions in excess shall be restrained by approved spring type mountings.

F. All mounting systems exposed to weather and other corrosive environments shall be protected with factory corrosion resistance. All metal parts of mountings (except springs and hardware) to be hot dip galvanized. Springs shall be cadmium plated and neoprene coated. Nuts and bolts shall be cadmium plated.

G. Where steel spring isolation systems are described in the specifications, the mounting assemblies shall utilize bare springs with the spring diameter not less than 0.8 of the loaded operating height of the spring. Each spring isolator shall be designed and installed so that the ends of the spring remain parallel during and after the spring installation. All isolators shall operate in the linear portion of their load versus deflection curve and have 50% excess capacity without becoming coil bound.

3.2 SUPPORT OF PIPING

A. The following water piping shall be resiliently supported:

1. All piping in equipment room.

2. Piping outside of equipment room within 50 feet or 100 diameters whichever is greater of connected rotating equipment.

3. All piping where exposed on roof.

4. Boiler breeching, emergency generator exhaust piping.

B. Resilient diagonal mountings or other approved devices shall be provided as required to limit piping motion due to equipment startup or shut down, to a maximum of 1/8 inch.

C. Water piping hanger rod isolators shall contain a steel spring in series with a 1/4 inch acoustical neoprene pad within a steel box retainer. The hanger rod isolator assembly shall be rigidly supported from the building structure. The installed hanger rod supported from the spring sub assembly shall not contact the steel box retainer and clearances in the isolator design shall be capable of accepting a 15 misalignment in any direction from the vertical.

D. The steel spring element of the assembly shall be designed to have a minimum surge frequency of 340 HZ and a minimum deflection of 3/4 inch.

E. Hanger rod isolators for steam and condensate piping including steam pressure reducing valve stations shall be supported by meals of neoprene-in-shear mountings providing a minimum static deflection of ½ inch.

F. Where supplementary steel is required to support piping, the supplementary steel shall be sized so that maximum deflection between supports does not exceed 0.08 inches and shall be resiliently supported from the building structure with mountings as described above. Supported piping from the supplementary steel shall be rigidly suspended or supported.

G. Precompressed type hanger rod isolators shall be provided for all water piping greater than 12 inch diameter and all supplementary steel supports. The precompression shall be factory set at 75% of rated deflection.

H. Where isolated water piping 8" and larger is supported directly below exposed steel beams, attachment to the beam shall be made by means of welded channel beam attachments located directly under the web of the beam. For piping 6" and smaller beam clamps may be used in lieu of welding subject to approval of beam clamp selection.

3.3 MAIN CHILLED & HOT WATER PIPING ANCHORS, GUIDES & SUPPORTS

A. Pipe riser guides, anchors and supports including piping anchors in mechanical equipment rooms or occupied spaces shall be isolated from the building structure such that there shall be no direct metal to metal contact of the piping with the building structure.

3.4 PIPING GUIDES

A. Steel guides shall be welded to the pipe at a maximum spacing of 90°. The outside diameter of the opposing guide bars shall be smaller than the inside diameter of the pipe riser clamp in accordance with standard field construction practice. Each end of the pipe guide shall be rigidly attached to an all directional pipe anchor isolation mounting which in turn, shall be rigidly fastened to the steel framing within the shaft.

B. The all directional pipe anchor isolation mountings shall consist of a telescoping arrangement of two sizes of steel tubing separated by a minimum of ½ inch thick heavy duty neoprene and canvas duck isolation pad. Vertical restraints shall be provided by similar material arranged to prevent vertical travel in either direction. The allowable load on the isolation material shall not exceed 500 psi.

C. Mountings shall be Type ADA - Mason Industries, Inc., or as approved.

D. Low temperature piping guides shall be constructed with a 360 10 gauge metal sleeve around the piping. The thermal insulation requirements for the piping shall be provided between the piping and the sleeve. Heavy duty neoprene and canvas duck isolation pad of thickness equal to thermal insulation requirements shall space the metal sleeve away from the piping with urethane or other suitable thermal insulation provided in the voids between the pipe-sleeve and isolation pan material. The metal sleeve outside diameter shall be smaller than the pipe riser clamp inside diameter in accordance with standard field construction practice. The pipe riser clamp shall be rigidly attached to the steel framing within the shaft.

3.5 ANCHORS

A. The pipe riser clamp at anchor points, shall be welded to the pipe and to pairs of vertical acoustical pipe anchor mountings which in turn, shall be rigidly fastened to the steel framing in the pipe shaft.

B. Acoustical pipe anchor mountings shall be Type VPA Mason Industries, Inc., or as approved.

3.6 SUPPORTS

A. Piping supports within shafts shall be provided with suitable bearing plates and two layers of 1/4 inch thick ribbed or waffled neoprene pad loaded for 50 psi maximum. The isolation pads shall be separated with 1/4 inch steel plate.

B. The isolation pads shall be one of the following or as approved:

Type W	-	M.I.I.
Type Shearflex	-	V.M.C.I.
Type 200N	-	V.E.C.

C. Piping isolation supports at the base of risers shall be two layers of ½ inch thick heavy duty neoprene and canvas duck isolation pad separated by 1/4 inch thick steel plate. Suitable bearing plates sized to provide a pad loading of 500 psi maximum shall be provided. The stanchion between the pipe and isolation support shall be welded to the pipe and welded or bolted to the isolation support. The isolation support shall be bolted to the floor slab with resilient sleeves and washers.

D. All pipe support resilient materials shall be HL Mason Industries, Inc., or as approved.

3.7 SHEET METAL & PIPING PENETRATIONS OF SHAFTS, FLOOR SLAB AND/OR PARTITIONS

A. There shall be no direct contact of Sheet Metal or piping with shaft walls, floor slabs and/or partition. All uninsulated sheet metal or piping shall be packed with caulking the full depth of the penetration.

3.8 SCHEDULE

A. See drawings for schedule of equipment

B. Provide vibration isolation per the Schedule below.

Equipment	Base Type	Isolator Types	Static Defl (in.)	Mason Ind. Type (5)
Fans (including AHU) Floor/Roof Supported VFD below 300 rpm 301 - 450 rpm 451 - 600 rpm 601 - 750 rpm 751 - 850 rpm 851 greater Suspended	Per Mfr. (7)	Spring Sprg/Neop	 (9) 4.0 3.0 3.5 2.0 1.5 1.0 (above+0.25)	SLF 30N
Mechanical and Domestic Pump (8) 5HP - greater	 Conc. Iner.	 Spring	 2.0	 KSL
Less than 5HP	Steel	Neoprene	0.50	MND
Associated equipment (assoc. w/ pumps and piping)	Per Mfr.	(1)	(1)	
Air Cooled Chillers	Per Mfr.	Sprng	2.0	SLR
Mechanical and Domestic Piping (3) Floor Supported Suspended Steam	as req'd	 Spring Sprg/Neop Neoprene	 1.0 1.25 0.35	 SLR 30N HD or ND
Generator (2)	Per Mfr.	Restr. Spring	1.0	SLR
Transformers (interior Dry Type) Floor Mounted (4) Suspended	 Per Mfr. Per Mfr.	 Neoprene Neoprene	 0.50 0.50	 ND HD

(1) Same as connected piping and pump.
(2) Manufacturer's standard springs.
(3) All water and steam piping with MER, but not less than 50 feet of equipment or pressure reducing stations, and all piping 4 inches and larger within and/or suspended from occupied floor.
(4) Internal isolation for transformer cores complying with the above tabulated isolation type and

ratings is acceptable.

(5) All isolation devices are to be Mason Industries or approved equal.

(6) Seismic restraints as required for project are to be separate of vibration isolation devices, and shall not degrade vibration isolation. Extent and type of seismic restraints by others.

(7) Vibration isolation scheme to consider fan operating force and provide thrust restraint and/or concrete inertia base in order to limit movement of fan to 1/4 inch at any operating point. Thrust restraints to have the same deflection as vibration isolation devices.

(8) In-line pumps to be mounted per manufacturer's recommendations.

(9) Isolator static deflection should be based on the VFD motor's lowest expected operating speed, per suggested schedule.

END OF SECTION 15240

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Insulation for ductwork, piping, and equipment as described.

1.2 RELATED DOCUMENTS

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

B. Section 15010 - Basic Mechanical Requirements

C. Section 15250 - Mechanical Insulation.

D. This section is a part of each Division 15000 Section.

E. Section 09900 - Painting: Painting insulation jackets.

1.3 REFERENCES

A. ANSI/ASTM C553 - Mineral Fiber Blanket and Felt Insulation.

B. ASTM C335 - Thermal Conductivity of Pipe Insulation.

C. ANSI/ASTM C612 - Mineral Fiber Block and Board Thermal Insulation.

D. ASTM E84 - Surface Burning Characteristics of Building Materials.

E. NFPA 255 - Surface Burning Characteristics of Building Materials.

F. UL 723 - Surface Burning Characteristics of Building Materials.

1.4 QUALITY ASSURANCE

A. Applicator: Company specializing in ductwork insulation application with three years minimum experience.

B. Insulation Materials: Insulation materials shall be manufactured at facilities certified and registered to conform to ISO 9000 Quality Standard.

C. Insulation shall have <u>composite</u> (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to the insulation) fire and smoke hazard ratings as tested by procedure ASTM E.84, NFPA 255 or UL 723 not exceeding:

Flame Spread:	25
Smoke Developed:	50

Accessories such as adhesives, mastics, cements, and tapes for fittings shall have the same component rating as listed above. All products or their shipping cartons shall bear a label indicating that flame and smoke ratings do not exceed requirements. Treatment of jackets or facings to impart flame and smoke-safety shall be permanent. The use of water soluble treatments is prohibited.

D. Asbestos shall not be used in the manufacture of insulation products.

1.5 SUBMITTALS

A. Submit product data under provisions of Section 01300.

B. Include product description, list of materials and thickness for each service, and locations.

C. Submit manufacturer's installation instructions under provisions of Section 01300.

PART 2 - PRODUCTS

2.1 GENERAL

A. All fiberglass insulation products, specified herein, shall be manufactured from recycled glass with a minimum of 30% post consume recycled content by weight. Contractor shall submit manufacturers certification of recycled content for approval.

1. All fiberglass insulation products used for ductwork, piping, or equipment insulation shall be formaldehyde free.

B. Adhesives:

1. All adhesives used on this project shall be of the type having limited capability to emit volatile organic compounds. Each adhesive shall meet the following emission factor limits:

Total VOC's	10.0 mg/m3/hr.
Formaldehyde	0.05mg/m3/hr.
2-Ethyl-1-Hexanol	3.0 mg/m3/hr.

2. The contractor shall submit a cut sheet and MSDS sheet for each adhesive to be used in the building mechanical system, highlighting VOC limits.

C. Sealants:

1. All sealants used in mechanical systems shall be of the low volatile organic compound emitting type. All sealants shall have emission characteristics that do not exceed a VOC limit of 250 g/L. The contractor

shall provide a cut sheet and MSDS sheet for each sealant to be used in the building mechanical system, highlighting VOC limits.

2.2 INSULATION FOR PIPING

A. Piping systems described shall be insulated as follows, including all flanges, fittings, valves, expansion joints, vents, drains and all other parts of the system. All piping subject to freezing such as in outdoor air or discharge plenums or outdoors shall be insulated with a minimum of 2" insulation.

B. Insulation on all cold surfaces must be applied with a continuous unbroken vapor seal. Hangers, supports, anchors, etc. that are secured directly to cold surfaces must be adequately insulated and vapor sealed to prevent condensation.

C. Insulation for outdoor piping shall be as described in Weatherproofing Finishes for Outdoor Insulation.

D. Schedule of Insulation Type and Minimum Thickness:

Piping System	**Thickness**	**Type**
Chilled water supply and return	1"	P-1
Up to 1 ½" 2" and over	1-1/2"	P-1
Hot-cold supply and return, mains and run outs ½" (45ºF to 170ºF)		
Up to 1-1/2" I.P.S.	1-1/2"	P-1
2" to 6" I.P.S.	2"	P-1
Over 6" I.P.S.	2-1/2"	P-1
Refrigerant suction	1-1/2"	P-1
Outdoor domestic water (for lengths see Plumbing Drawings)	2"	P-1
Drain from A.C. units, fan coil units, cooling coil drip pans, and miscellaneous piping subject to sweating.	½"	P-2
Domestic make-up water.	½"	P-2
Hot water supply and return (100ºF to 205ºF)		
up to 1-1/2"	1"	P-3
2" and above	2"	P-3

Piping System	Thickness	Type
Low pressure steam (0 to 15 psig) condensate return, humidification steam and condensate pump discharge up to 1-12" I.P.S. 2" to 6" I.P.S. over 6"	1-1/2" 3" 3-1/2"	P-3 P-3 P-3
Steam humidification piping	Same as low pressure steam piping.	Same as low pressure steam piping.
Snow melting supply and return. Up to 1-1/2" 2" and above	 1" 2"	 P-3 P-3
Fuel oil supply and return.	1"	P-3
Steam safety and relief.	1"	P-3
Engine exhaust and muffler.	3"	P-4

E. Type P-1 Glass Fiber for Cold Pipes:

1. Insulation shall be glass fiber with a maximum K factor of .24 at 75 degrees F mean temperature with factory applied all-service jacket.

2. Insulation shall be rigid, molded, one-piece, fiberglass insulation that is bonded with thermosetting resin, similar to Schuller Micro-Lok with AP-T Plus Jacket.

3. The longitudinal lap of the All Purpose Jacket shall have a pressure sensitive tape lap sealing system. Butt joints shall be sealed using manufacturer supplied butt strips.

4. All fittings, valves, flanges and pipe terminations shall be fully insulated with glass fiber insulation and molded fitting covers. Thickness of insulation shall be at least as great as that on the adjoining pipe and shall be vapor sealed.

5. Flange insulation shall extend a minimum of 1" beyond the end of the bolts, and the bolt area shall be filled with Mineral Wool Cement.

F. Type P-2 Glass Fiber for Anti-Sweat Insulation:

1. Same material and application techniques as for Type P-1.

G. Type P-3 Glass Fiber for Hot Pipes:

1. Insulation shall be glass fiber with a maximum K factor of .24 at 75 degrees mean temperature and shall be furnished with a factory applied all-service jacket.

2. Insulation shall be capable of continuous service at a pipe temperature of 450°F without oxidation, burnout of binders, or development of odors or smoke.

3. Insulation shall be rigid, molded, one piece fiberglass insulation that is bonded with thermosetting resin, similar to Schuller Micro-Lok with AP-T Plus Jacket.

4. The longitudinal lap of the All Purpose Jacket shall have a pressure sensitive tape sealing system. Butt joints shall be sealed using manufacturer supplied butt strips.

5. All fittings, valves, flanges and pipe terminations shall be fully insulated with glass fiber insulation and molded fitting covers. Thickness of insulation shall be at least as great as that on the adjoining pipe.

6. Flange insulation shall extend a minimum of 1" beyond the end of the bolts, and the bolt area shall be filled with Mineral Wool Cement.

H. Type P-4 Calcium Silicate Pipe Insulation:

1. Insulation shall be 11 lbs per cu. ft. density molded hydrous calcium silicate with a maximum K factor of 0.42 at 200 degrees F. mean temperature. Insulation shall be fastened in place with 16 gauge copper-clad wire on l8" maximum centers.

2. Fittings and valves for pipe sizes smaller than 4" shall be insulated and finished with Insulating and Finishing Cement to a thickness equal to the adjoining pipe insulation. Fittings and valves for pipe sizes 4" and larger shall be insulated with segments of the molded insulation wired securely in place and finished with a smoothing coat of finishing cement.

I. Provide insulation of thickness shown for piping which is electrically traced. Note that insulation is to be provided by this trade over electric tracing provided by the electrical trade. Insulation Types are as specified under "Insulation For Piping".

1. The following piping shall be specially insulated:

   (a) Outdoor Condenser Water

   (b) Outdoor Domestic Water

2. Staples for fastening shall not be used in order to prevent possible short circuiting of electric wires. Use stainless steel bands.
3. All piping shall be insulated as described under "Insulation For Piping" except thicknesses shall not be less than as follows:

2½" for all pipe sizes.	-20ºF OUTDOOR DESIGN

2.3 INSULATION FOR SHEET METAL

A. Note that ductwork and casings which are acoustically lined, as described elsewhere, need not be insulated on the exterior.

B. The exception to the above is that acoustically lined ductwork above roof shall be insulated on the exterior.

C. Insulate sheet metal as follows:

1. All air conditioned and/or heated low pressure supply ductwork from fan discharge and from devices which reduce air pressure to diffusers, grilles and registers including diffuser plenums - 1-1/2" Type D-1 for round ducts and concealed rectangular ducts - 1" Type D-2 for exposed rectangular ducts.

   (a) Note that insulation (with vapor barrier) shall be continuous across all duct joints, hot water reheat coil pipe bends (insulated end caps), diffusers, etc. so as to provide a continuous, fully insulated with uninterrupted vapor barrier from the fan discharge to the diffusers.

2. All return air ductwork in non-conditioned spaces shall be insulated similar to low pressure supply ductwork.

   (a) Ceilings of conditioned spaces shall not require return ductwork insulation except for ceiling space located below roofs where return ductwork shall be insulated similar to low pressure supply ductwork.

   (b) Note that insulation (with vapor barrier) shall be continuous across all duct joints, hot water reheat coil pipe bends (insulated end caps), diffusers, etc. so as to provide a continuous, fully insulated with uninterrupted vapor barrier from the fan discharge to the diffusers.

3. All medium pressure ductwork from fan discharge to any air terminal device which reduces air pressure -1-1/2" Type D-1 for round ducts and concealed rectangular. 1" Type D-2 for exposed rectangular ducts. All low pressure ductwork from air terminal device which reduces pressure to diffusers, grilles, and registers - 1-1/2" Type D-1.

   (a) Note that insulation (with vapor barrier) shall be continuous across all duct joints, hot water reheat coil pipe bends (insulated end caps) diffusers, etc. so as to provide a continuous, fully insulated with uninterrupted vapor barrier from the fan discharge to the diffusers.

4. Ducts and sheet metal plenums behind louvers containing all or a percentage of outside air on inlet side of air handling units and ventilation fans - 2" Type D-2.

5. All supply air sheet metal plenums - 2" Type D-2.

6. Outdoor ducts whether acoustically lined or not shall be insulated with 2" thick type D-2 and then weather proofed as specified under Weatherproofing Finishes for Outdoor Insulation. Exceptions: Toilet exhaust, general exhaust, smoke exhaust and stair pressurization ductwork.

7. Exhaust air ductwork from automatic dampers to discharge louvers (including sheet metal plenums behind louvers) - 2" type D-2.

8. Non air conditioned and non heated outside air supply (except in unheated areas such as garages) - 2" type D-1 for concealed ducts, 2" type D-2 for exposed ducts.

9. Non heated air exhaust (i.e., unheated garage, etc.) running through heated or air conditioned spaces - 2" type D-3 for concealed ducts, 2" type D-4 for exposed ducts.

10. All outside air supply (other than garage) - 2" Type D-2.

11. Exhaust air ductwork from discharge of emergency generator fan to louver (including duct plenum behind louver) - 2" Type D-2.

D. Type D-1 Flexible Duct Insulation With Vapor Barrier:

1. Flexible duct insulation shall be 1 lb per cu. ft. density glass fiber with a maximum K factor of 0.29 at 75 degrees F. mean temperature, with reinforced foil-faced, flame resistant kraft vapor barrier.

2. Insulation shall be secured with duct adhesive. All joints shall be sealed by adhering a 2" sealing lap at all joints with vapor barrier adhesive or 3" strips of vapor barrier jacket applied with vapor barrier adhesive. Insulation shall then be fastened with 16 gauge copper-clad wire or fiberglass cord on 12" centers. On ducts over 24" wide, welded pins & clips shall be used on the underside.

3. Exposed round shall have a white vinyl reinforced foil vapor barrier. Application same except wires shall be omitted and blanket shall be secured by stapling 2" longitudinal lap. Staples shall be coated with vapor barrier coating.

E. Type D-2 Rigid Duct Insulation With Vapor Barrier:

1. Rigid duct insulation shall be 4.2 lbs per cu. ft. density glass fiber with

maximum K factor of .24 at 75 degrees F mean temperature with vapor barrier facing.

2. Insulation shall be impaled over welded pins applied to duct surface on 12" to 18" centers. Use a minimum of two rows of fasteners on each side of duct. Secure insulation with suitable speed washers or clips firmly imbedded into insulation.

3. All joints and voids in the insulation shall be filled with Mineral Wool Cement. All joints, speed washers and breaks in the vapor barrier shall be sealed with 3" wide strips of the vapor barrier facing adhered with vapor barrier adhesive.

4. Exposed duct work shall have a white reinforced foil vapor barrier facing. Care shall be taken in sealing joints speed washers, etc. with matching strips of vapor barrier to insure good appearance.

F. Type D-3 Flexible Duct Insulation For Hot Ducts:

1. Flexible duct insulation shall be 1 lb per cu. ft. density glass fiber with a maximum K factor of 0.29 at 75 degrees F. mean temperature.

2. Insulation shall be secured with a Benjamin-Foster 85-20 adhesive. Butt all edges of insulation on exposed ducts and lap all edges of insulation 2" on concealed ducts. Insulation shall then be fastened with 16 gauge copper-clad wire on 12" centers.

3. Exposed ducts shall have white, reinforced foil facing. Secured by stapling a 2" longitudinal lap and eliminate wire.

G. Type D-4 Rigid Duct Insulation For Hot Ducts:

1. Rigid duct insulation shall be 4.2 lbs per cu. ft. density glass fiber with maximum K factor of .24 at 75 degrees F mean temperature with fire retardant vapor barrier facing.

2. Insulation shall be impaled over welded pins applied to duct surface on 12" to 18" centers. Use a minimum of two rows of fasteners on each side of duct. Secure insulation with suitable speed washers or clips firmly imbedded into insulation.

3. All joints and voids in the insulation shall be filled with Mineral Wool Cement.

4. Exposed ductwork shall have a white vinyl reinforced foil vapor barrier

facing. Care shall be taken in sealing joints speed washers, etc. with matching strips of vapor barrier to insure good appearance.

2.4 INSULATION FOR EQUIPMENT, BREECHINGS, & KITCHEN EXHAUST

A. The following Cold Equipment shall be insulated with Vapor Barrier Board Insulation using Type E-1 insulation.

1. Centrifugal Refrigeration Equipment - 2 inches.

2. Evaporators, Dehumidifiers and Exchangers - 2 inches.

3. Chilled Water Pumps, Secondary Water Pumps, and Expansion Tanks - 1 inch.

4. Single Inlet Fans Downstream of Cooling Coils - 2 inches.

B. The following Hot Equipment shall be insulated with Semi-Rigid Board Insulation using Type E-2 Insulation.

C. The following Hot Equipment shall be insulated w ith Semi-Rigid Board Insulation using Type E-2 Insulation.

1. Hot Water Expansion Tanks -)1 inch.
)250ºF
)Generators - 1 inch.
)250ºF max.

D. The following Equipment and Systems shall be insulated with high temperature block insulation using Type E-3 insulation.

1. Boiler - 2 inch -)Packaged Boilers are usually insulated at Factory.
2. Boiler Breechings - 2 inch.
3. Kitchen Range Exhaust Ducts, Casings, and Fans - 2 inch.
4. Branch ducts from other equipment in kitchen area such as dishwasher, etc. - 1 inch.

E. Type E-1 Glass Fiber Rigid Equipment Insulation With Vapor Barrier:

1. Insulation shall be 4.2 lb. per cu. ft. density glass fiber with vapor barrier facing and having a maximum K factor of 0.24 at 75 degrees F mean temperature.

2. Insulation shall be firmly held in place with copper clad wire or pins and clips on 12" centers.

3. All joints and voids in the insulation shall be filled with mineral wool

cement. All joints and breaks in the vapor barrier shall be sealed with strips of the vapor barrier facing adhered with vapor barrier adhesive.

4. Finish shall consist of imbedding an open weave glass fabric (20 x 20) into wet coating of lagging adhesive over-lapping the seams at least 2". A finish coat of lagging adhesive shall then be applied.

5. Sections of equipment requiring periodic servicing such as heads and pumps shall be insulated with sheet metal covers lined with 4.2 lb. density fiber glass board.

F. Type E-2 Glass Fiber Rigid Equipment Insulation:

1. Insulation shall be 4.2 lb. per cubic foot density glass fiber having a maximum K factor of .24 at 75 degrees F mean temperature.

2. Insulation shall be firmly held in place with copper-clad wire or pins and clips on 12" centers.

3. All joints and voids in the insulation shall be filled with mineral wool cement.

4. Over the insulation apply 1" galvanized wire netting secured to the bands or wires and pulled down tight. They apply 1 coat of Insulating and Finishing Cement troweled to a smooth finish.

5. Exposed equipment shall be finished by embedding open weave glass fabric (20 x 20) into wet coating of lagging adhesive overlapping seams 2". A finished coat of lagging adhesive shall then be applied.

6. Sections of equipment requiring periodic servicing such as heads and pumps shall be insulated with sheet metal covers lined with 4.2 lb. density fiber glass board.

G. Type E-3 High Temperature Block Insulation:

1. High temperature insulation shall be 11 lbs. per cu. ft. density molded hydrous calcium silicate with a maximum K factor of 0.42 at 200 degrees F mean temperature.

2. Insulation shall be securely wired in place with copper clad wire or galvanized steel bands (½" x .015) on 12" centers.

3. All joints and voids of insulation shall be filled and pointed with mineral wool cement.

4. Over the insulation apply 1" galvanized wire netting secured to the bands or wires and pulled down tight. They apply 1/4" thick coat of Insulating and Finishing Cement trowelled to a smooth finish. This applies to both

exposed and concealed work.

5. For kitchen exhaust ducts exposed in finished spaces cover the cement finish with glass cloth set in adhesive.

6. Sections of equipment requiring periodic servicing shall be insulated with aluminum covers lined with the same thickness of material as the adjoining insulation.

2.5 WEATHERPROOFING FINISHES FOR OUTDOOR INSULATION

A. Outdoor Round Duct:

1. Ductwork shall be insulated as specified under “Insulation for Sheet Metal” and provided with a weatherproof finish as described herein.

2. Finish with a .016" thick aluminum jacket which has a factory applied moisture barrier. For all applications where it is available, the jacketing shall be factory attached to the insulation and installed per manufacturer's recommendation.

3. Where field applied jacketing must be used it shall be applied with 2" overlap facing down from the weather and shall be secured with an aluminum band (½" x .020"), and seals applied on 12" centers with bands applied directly over butt overlaps. As an alternate the jacketing may be applied with Pli-Grip Rivets. Where jacketing is cut out or abuts an uninsulated surface, the joint shall be sealed with Insul-Coustic Sure Joint 405, or BF 30-45 Foam Seal.

4. Fittings shall be insulated and finished with mitered sections of the insulation with factory attached aluminum jackets installed per manufacturer's recommendation.

B. Outdoor Equipment, Rectangular Duct Work and Irregular Surfaces:

1. Ductwork, equipment and irregular surfaces shall be insulated as specified under this section and provided with a weatherproof finish as described herein.

2. The surfaces shall be weather protected with two coats of Insulcoustic VI-AC Mastic, I-C 551, or Benjamin Foster GPM Mastic with open weave glass cloth membrane imbedded between the coats. The total thickness of the coating shall be a minimum of 1/8".

C. Outdoor Piping:

1. Piping shall be insulated as specified under “Insulation for Piping” and provided with a weatherproof finish as described herein.

2. Finish with a .016" thick aluminum jacket which has a factory applied moisture barrier. For all applications where it is available, the jacketing shall be factory attached to the insulation and installed per manufacturer's recommendation.

3. Where field applied jacketing must be used, it shall be applied with 2" overlap facing down from the weather and shall be secured with an aluminum band (½" x .020"), and seals applied on 12" centers with bands applied directly over butt overlaps. As an alternate, the jacketing may be applied with Pli-Grip Rivets. Where jacketing is cut out or abuts an uninsulated surface, the joint shall be sealed with Insul-Coustic Sure Joint 405, or BF 30-45 Foam seal.

4. Fittings and valves shall be insulated and finished with mitered sections of the insulation with factory attached aluminum jackets installed per manufacturer's recommendation.

PART 3 - EXECUTION

3.1 PREPARATION

A. Install materials after ductwork has been tested and approved.

B. Clean surfaces for adhesives.

C. Do not startup and operate chilled water system prior to completion of insulation for the entire chilled water piping system and complete closure of building from the external atmosphere.

D. Do not operate air handling system with conditioned air prior to completion of insulation of the entire duct distribution system for that air handling system.

3.2 INSTALLATION

A. Insulation shall be applied on clean dry surfaces, after inspection and release for insulation application.

B. Insulation shall be continuous through wall and ceiling openings and sleeves. Where insulated piping or ductwork pierces fire rated partitions, walls, and floors, substitute anhydrous calcium silicate insulation with vapor barrier in lieu of fiberglass for a minimum of 8" from wall, to produce a hard surface for fire resistive packing.

C. 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.

D. Inserts shall be installed at hangers for cold 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. Inserts shall have sufficient compressive strength so that when used in combination with a sheet metal shield, they support the weight of the pipe and the fluid in it without crushing the insulation.

3.3 SCHEDULE

A. As described under products.

END OF SECTION 15250

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following plumbing specialties:

1. Backflow preventers.
2. Water regulators.
3. Balancing valves.
4. Thermostatic water mixing valves.
5. Water tempering valves.
6. Strainers.
7. Hose stations.
8. Key-operation hydrants.
9. Wheel-handle wall hydrants.
10. Trap seal primer valves.
11. Drain valves.
12. Miscellaneous piping specialties.
13. Sleeve penetration systems.
14. Flashing materials.
15. Cleanouts.
16. Floor drains.
17. Trench drains.
18. Roof drains.
19. Solids interceptors.

B. Related Sections include the following:

1. Division 15 Section "Plumbing - Meters and Gages" for water meters, thermometers, and pressure gages.

1.3 DEFINITIONS

A. The following are industry abbreviations for plastic piping materials:

1. ABS: Acrylonitrile-butadiene-styrene plastic.

2. PE: Polyethylene plastic.

3. PUR: Polyurethane plastic.

4. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing piping systems with following minimum working-pressure ratings, unless otherwise indicated:

1. Domestic Water Piping: 125 psig (860 kPa).

2. Sanitary Waste and Vent Piping: 10-foot head of water (30 kPa).

3. Storm Drainage Piping: 10-foot head of water (30 kPa).

4. Force-Main Piping: 100 psig (690 kPa).

1.5 SUBMITTALS

A. Product Data: Include rated capacities and shipping, installed, and operating weights. Indicate materials, finishes, dimensions, required clearances, and methods of assembly of components; and piping and wiring connections for the following:

1. Backflow preventers and water regulators.

2. Balancing valves, water filters, and strainers.

3. Thermostatic water mixing valves and water tempering valves.

4. Water hammer arresters, air vents, and trap seal primer valves and systems.

5. Drain valves, hose bibbs, hydrants, and hose stations.

6. Outlet boxes and washer-supply outlets.

7. cleanouts, floor drains, open receptors, trench drains, and roof drains.

8. Air-admittance valves, vent caps, vent terminals, and roof flashing assemblies.

9. solids interceptors.

10. Sleeve penetration systems.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field test reports.

D. Maintenance Data: For plumbing specialties to include in maintenance manuals. Include the following:

1. Backflow preventers and water regulators.

2. Thermostatic water mixing valves and water tempering valves.

3. Trap seal primer valves and systems.

4. Hose stations and hydrants.

5. solids interceptors.

1.6 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of plumbing specialties and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

B. Plumbing specialties shall bear label, stamp, or other markings of specified testing agency.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for piping materials and installation.

E. NSF Compliance:

1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components. Include marking "NSF-pw" on plastic potable-water piping and "NSF-dwv" on plastic drain, waste, and vent piping.

2. Comply with NSF 61, "Drinking Water System Components--Health Effects, Sections 1 through 9," for potable domestic water plumbing specialties.

1.7 EXTRA MATERIALS

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

1. Water Filter Cartridges: Equal to 200 percent of amount installed for each type and size indicated.

2. Operating Key Handles: Equal to 100 percent of amount installed for each key-operated hose bibb and hydrant installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the products specified.

2.2 BACKFLOW PREVENTERS

A. Manufacturers:

1. Ames Co., Inc.

2. Cla-Val Co.

3. CMB Industries, Inc.; Febco Backflow Preventers.

4. Mueller Co.; Hersey Meters Div.

5. Watts Industries, Inc.; Water Products Div.

6. Zurn Industries, Inc.; Wilkins Div.

B. General: ASSE standard, backflow preventers.

1. NPS 2 (DN 50) and Smaller: Bronze body with threaded ends.

2. NPS 2-1/2 (DN 65) and Larger: Bronze, cast-iron, steel, or stainless-steel body with flanged ends.

   (a) Interior Lining: AWWA C550 or FDA-approved, epoxy coating for backflow preventers having cast-iron or steel body.

3. Interior Components: Corrosion-resistant materials.

4. Exterior Finish: Polished chrome plate if used in chrome-plated piping system.

5. Strainer: On inlet.

C. Pipe-Applied, Atmospheric-Type Vacuum Breakers: ASSE 1001, with floating disc and atmospheric vent.

D. Hose-Connection Vacuum Breakers: ASSE 1011, nickel plated, with nonremovable and manual drain features, and ASME B1.20.7, garden-hose threads on outlet. Units attached to rough-bronze-finish hose connections may be rough bronze.

E. Intermediate Atmospheric-Vent Backflow Preventers: ASSE 1012, suitable for continuous pressure application. Include inlet screen and two independent check valves with intermediate atmospheric vent.

F. Reduced-Pressure-Principle Backflow Preventers: ASSE 1013, suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and strainer on inlet; test cocks; and pressure-differential relief valve with ASME A112.1.2 air-gap fitting located between two positive-seating check valves.

1. Pressure Loss: 12 psig (83 kPa) maximum, through middle 1/3 of flow range.

G. Double-Check Backflow Prevention Assemblies: ASSE 1015, suitable for continuous pressure application. Include shutoff valves on inlet and outlet, and strainer on inlet; test cocks; and two positive-seating check valves.

1. Pressure Loss: 5 psig (35 kPa) maximum, through middle 1/3 of flow range.

H. Antisiphon-Pressure-Type Vacuum Breakers: ASSE 1020, suitable for continuous pressure application. Include shutoff valves, spring-loaded check valve, spring-loaded floating disc, test cocks, and atmospheric vent.

1. Pressure Loss: 5 psig (35 kPa) maximum, through middle 1/3 of flow range.

I. Dual-Check-Valve-Type Backflow Preventers: ASSE 1024, suitable for continuous pressure application. Include union inlet and two independent check valves.

J. Dual-Check-Valve-Type Backflow Preventers: ASSE 1032, suitable for continuous pressure application for carbonated beverage dispensers. Include stainless-steel body; primary and secondary checks; ball check; intermediate atmospheric-vent port for relieving carbon dioxide; and threaded ends, NPS 3/8 (DN 10).

K. Reduced-Pressure Detector Assembly Backflow Preventers: ASSE 1047, FM approved or UL listed, and suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and strainer on inlet. Include test cocks; pressure-differential relief valve with ASME A112.1.2 air-gap fitting located between two positive-seating check valves; and bypass with displacement-type water meter, valves, and reduced-pressure backflow preventer.

1. Pressure Loss: 12 psig (83 kPa) maximum, through middle 1/3 of flow range.

L. Double-Check Detector Assembly Backflow Preventers: ASSE 1048, FM approved or UL listed, and suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and strainer on inlet. Include test cocks; two positive-seating check valves; and bypass with displacement-type water meter, valves, and double-check backflow preventer.

1. Pressure Loss: 5 psig (35 kPa) maximum, through middle 1/3 of flow range.

M. Hose-Connection Backflow Preventers: ASSE 1052, suitable for at least 3-gpm (0.19-L/s) flow and applications with up to 10-foot head of water (30-kPa) back pressure. Include two check valves; intermediate atmospheric vent; and nonremovable, ASME B1.20.7, garden-hose threads on outlet.

N. Back-Siphonage Backflow Vacuum Breakers: ASSE 1056, suitable for continuous pressure and backflow applications. Include shutoff valves, check valve, test cocks, and vacuum vent.

2.3 WATER REGULATORS

A. Manufacturers:.

1. Cla-Val Co..

2. Watts Industries, Inc.; Water Products Div.

3. Zurn Industries, Inc.; Wilkins Div.

B. General: ASSE 1003, water regulators, rated for initial working pressure of 150 psig (1035 kPa) minimum. Include integral factory-installed or separate field-installed, Y-pattern strainer.

1. NPS 2 (DN 50) and Smaller: Bronze body with threaded ends.

(a) General-Duty Service: Single-seated, direct operated, unless otherwise indicated.

(b) Booster Heater Water Supply: Single-seated, direct operated with integral bypass.

2. NPS 2-1/2 (DN 65) and Larger: Bronze or cast-iron body with flanged ends. Include AWWA C550 or FDA-approved, interior epoxy coating for regulators with cast-iron body.

(a) Type: Single-seated, direct operated.

(b) Type: Pilot-operated, single- or double-seated, cast-iron-body main valve, with bronze-body pilot valve.

3. Interior Components: Corrosion-resistant materials.

4. Exterior Finish: Polished chrome plate if used in chrome-plated piping system.

5. Strainer on inlet.

2.4 BALANCING VALVES

A. Balancing Valves: Adjustable, with two readout ports and memory setting indicator. Include manufacturer's standard hoses, fittings, valves, differential pressure meter, and carrying case.

1. Manufacturers:

   (a) Amtrol, Inc.

   (b) Armstrong Pumps, Inc.

   (c) Armstrong-Yoshitake, Inc..

   (d) ITT Industries; Bell & Gossett Div.

   (e) Taco, Inc.

   (f) Watts Industries, Inc.; Water Products Div.

2. NPS 2 (DN 50) and Smaller: Bronze body with brass ball, adjustment knob, calibrated nameplate, and threaded or solder-joint ends.

3. NPS 2 (DN 50) and Smaller: Bronze, Y-pattern body with adjustment knob and threaded ends.

4. NPS 2-1/2 (DN 65) and Larger: Cast-iron, Y-pattern body with bronze disc and flanged or grooved ends.

2.5 THERMOSTATIC WATER MIXING VALVES 60° - 85°

A. Manufacturers:

1. Lawler Manufacturing Company, Inc.

2. Leonard Valve Company.

3. Mark Controls Corp.; Powers Process Controls.

4. Symmons Industries, Inc.

B. General: ASSE 1017, manually adjustable, thermostatic water mixing valve with bronze body. Include check stop and union on hot- and cold-water-supply inlets, adjustable temperature setting, and thermometer.

1. Type: Bimetal thermostat, operation and pressure rating 125 psig (860 kPa) minimum.

2. Type: Liquid-filled motor, operation and pressure rating 100 psig (690 kPa) minimum.

C. Thermostatic Water Mixing Valves: Unit, with the following:

1. Piping, valves, and unions. Include thermometer if not in cabinet.

2. Piping Component Finish: Polished chrome plate.

3. Cabinet: [**Recessed**] [**Surface**]-mounting steel box with steel hinged door, white enameled finish, and thermometer in front.

4. Cabinet: [**Recessed**] [**Surface**]-mounting stainless-steel box with stainless-steel hinged door and thermometer in front.

D. Manifolded, Thermostatic Water Mixing-Valve Assemblies: Factory-fabricated unit consisting of parallel arrangement of thermostatic water mixing valves.

1. Arrangement: One large-flow, thermostatic water mixing valve with flow-control valve, pressure regulator, inlet and outlet pressure gages, and one small-flow, thermostatic water mixing valve with flow-control valve. Include outlet thermometer, factory- or field-installed inlet and outlet valves, and other indicated options.

2. Include piping, valves, and unions.

3. Piping Component Finish: Polished chrome plate.

4. Cabinet: [**Recessed**] [**Surface**]-mounting steel box with steel hinged door, white enameled finish, and thermometer in front.

5. Cabinet: [**Recessed**] [**Surface**]-mounting stainless-steel box with stainless-steel hinged door and thermometer in front.

2.6 WATER TEMPERING VALVES

A. Manufacturers:

1. Holby Valve Co., Inc.

2. Watts Industries, Inc.; Water Products Div.

B. General: Manually adjustable, thermostatically controlled water tempering valve; bronze body; and adjustable temperature setting.

C. System Water Tempering Valves: Piston or discs controlling both hot- and cold-water flow, capable of limited antiscald protection. Include threaded inlets and outlet.

1. Finish: Chrome plated.

D. Limited-Volume, Water Tempering Valves: Solder-joint inlets and NPS 3/4 (DN 20) maximum outlet.

2.7 STRAINERS

A. Strainers: Y-pattern, unless otherwise indicated, and full size of connecting piping. Include ASTM A 666, Type 304, stainless-steel screens with 3/64-inch (1.2-mm) round perforations, unless otherwise indicated.

1. Pressure Rating: 125-psig (860-kPa) minimum steam working pressure, unless otherwise indicated.

2. NPS 2 (DN 50) and Smaller: Bronze body, with female threaded ends.

3. NPS 2-1/2 (DN 65) and Larger: Cast-iron body, with interior AWWA C550 or FDA-approved, epoxy coating and flanged ends.

4. Y-Pattern Strainers: Screwed screen retainer with centered blowdown.

(a) Drain: Factory- or field-installed, hose-end drain valve.

5. T-Pattern Strainers: Malleable-iron or ductile-iron body with grooved ends; access end cap with drain plug and access coupling with rubber gasket.

6. Basket Strainers: Bolted flange or clamp cover, and basket with lift-out handle.

(a) Type: Simplex with one basket.

(b) Drain: Factory- or field-installed, hose-end drain valve.

B. Drainage Basket Strainers: Non-pressure-rated, cast-iron or coated-steel body; with bolted flange or clamp cover and drain with plug.

1. Basket: Bronze or stainless steel with 1/8- or 3/16-inch- (3.2- or 4.8-mm-) diameter holes and lift-out handle.

2. Female threaded ends for NPS 2 (DN 50) and smaller, and flanged ends for NPS 2-1/2 (DN 65) and larger.

2.8 KEY-OPERATION HYDRANTS

A. Manufacturers:

1. Josam Co.

2. Murdock, Inc.

3. Simmons Manufacturing Co.

4. Smith, Jay R. Mfg. Co.

5. Tyler Pipe; Wade Div.

6. Watts Industries, Inc.; Drainage Products Div.

7. Woodford Manufacturing Co.

8. Zurn Industries, Inc.; Jonespec Div.

9. Zurn Industries, Inc.; Specification Drainage Operation.

B. General: ASME A112.21.3M, key-operation hydrant with pressure rating of 125 psig (860 kPa).

1. Inlet: NPS 3/4 or NPS 1 (DN 20 or DN 25) threaded or solder joint.

2. Outlet: ASME B1.20.7, garden-hose threads.

3. Operating Keys: Two with each key-operation hydrant.

C. Nonfreeze Exposed-Outlet Wall Hydrants: ASSE 1019, self-drainable with integral nonremovable hose-connection [**vacuum breaker**] [**or**] [**backflow preventer**], casing and operating rod to match wall thickness, projecting outlet, and wall clamp.

1. Classification: Type A, for automatic draining with hose removed or Type B, for automatic draining with hose removed or with hose attached and nozzle closed.

2. Nozzle and Wall Plate Finish: Polished nickel bronze.

D. Nonfreeze Concealed-Outlet Wall Hydrants: ASSE 1019, self-drainable with flush-mounting box with cover, integral nonremovable hose-connection vacuum breaker or backflow preventer, casing and operating rod to match wall thickness, concealed outlet, and wall clamp.

1. Classification: Type A, for automatic draining with hose removed or Type B, for automatic draining with hose removed or with hose attached and nozzle closed.

2. Box and Cover Finish: Polished nickel bronze.

E. Moderate-Climate, Concealed-Outlet Wall Hydrants: ASSE 1019, self-drainable with flush-mounting box with cover, integral nonremovable hose-connection vacuum breaker or backflow preventer, and concealed outlet.

1. Classification: Type A, for automatic draining with hose removed or Type B, for automatic draining with hose removed or with hose attached and nozzle closed.

2. Box and Cover Finish: Polished nickel bronze.

3. Box and Cover Finish: [**Satin**] [**Polished**] chrome plate.

F. Hot and Cold, Nonfreeze Concealed-Outlet Wall Hydrants: With deep flush-mounting box with cover; hot- and cold-water casings and operating rods to match wall thickness; concealed outlet; wall clamps; and factory- or field-installed, nonremovable and manual drain-type, hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.

1. Box and Cover Finish: Polished nickel bronze.

G. Nonfreeze Concealed-Outlet Ground Hydrants: Draining type with flush-mounting box with cover, casing and operating rod of at least length required for burial of valve below frost line, drain hole, and garden-hose threads complying with ASME B1.20.7 on outlet.

1. Box and Cover Finish: Polished nickel bronze.

H. Nonfreeze Exposed-Outlet Ground Post Hydrants: Draining type for key or lever operation with bronze casing, cast-iron, or cast-aluminum casing guard; casing and operating rod of at least length required for burial of valve below frost line; drain hole; nonremovable, drainable hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052; and garden-hose threads complying with ASME B1.20.7 on outlet.

2.9 WHEEL-HANDLE WALL HYDRANTS

A. Manufacturers:

1. Arrowhead Brass Products, Inc.

2. B & K Industries, Inc.

3. Mansfield Plumbing Products, Inc.

4. NIBCO INC.

5. Sioux Chief Manufacturing Co., Inc.

6. Watts Industries, Inc.; Water Products Div.

7. Woodford Manufacturing Co.

8. Zurn Industries, Inc.; Jonespec Div.

B. Description: Frost-proof design similar to ASME A112.21.3M, for wall mounting with wheel-handle operation, NPS 1/2 or NPS 3/4 (DN 15 or DN 20) threaded or solder-joint inlet, casing and operating rod to match wall thickness, and projecting outlet with ASME B1.20.7 garden-hose threads on outlet. Include wall clamp; integral vacuum breaker or nonremovable, drainable hose-connection vacuum breaker complying with ASSE 1011] [or] [backflow preventer complying with ASSE

1052; and garden-hose threads complying with ASME B1.20.7 on outlet.

2.10 TRAP SEAL PRIMER VALVES

A. Supply-Type Trap Seal Primer Valves: ASSE 1018, water-supply-fed type, with the following characteristics:

1. Manufacturers:

   (a) Josam Co.

   (b) MIFAB Manufacturing, Inc.

   (c) Precision Plumbing Products, Inc.

   (d) Smith, Jay R. Mfg. Co.

   (e) Tyler Pipe; Wade Div.

   (f) Watts Industries, Inc.; Drainage Products Div.

   (g) Watts Industries, Inc.; Water Products Div.

   (h) Zurn Industries, Inc.; Jonespec Div.

   (i) Zurn Industries, Inc.; Specification Drainage Operation.

2. 125-psig (860-kPa) minimum working pressure.

3. Bronze body with atmospheric-vented drain chamber.

4. Inlet and Outlet Connections: NPS 1/2 (DN 15) threaded, union, or solder joint.

5. Gravity Drain Outlet Connection: NPS 1/2 (DN 15) threaded or solder joint.

6. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.11 DRAIN VALVES

A. Hose-End Drain Valves: MSS SP-110, NPS 3/4 (DN 20) ball valve, rated for 400-psig (2760-kPa) minimum CWP. Include two-piece, copper-alloy body with standard port, chrome-plated brass ball, replaceable seats and seals, blowout-proof stem, and vinyl-covered steel handle.

1. Inlet: Threaded or solder joint.

2. Outlet: Short-threaded nipple with ASME B1.20.7, garden-hose threads and cap.

B. Hose-End Drain Valve: MSS SP-80, gate valve, Class 125, ASTM B 62 bronze body, with NPS 3/4 (DN 20) threaded or solder-joint inlet and ASME B1.20.7, garden-hose threads on outlet and cap. Hose bibbs are prohibited for this application.

C. Stop-and-Waste Drain Valves: MSS SP-110, ball valve, rated for 200-psig (1380-kPa) minimum CWP or MSS SP-80, Class 125, gate valve; ASTM B 62 bronze body, with NPS 1/8 (DN 6) side drain outlet and cap.

2.12 MISCELLANEOUS PIPING SPECIALTIES

A. Water Hammer Arresters: ASSE 1010 or PDI-WH 201, metal-bellows type with pressurized metal cushioning chamber. Sizes indicated are based on ASSE 1010 or PDI-WH 201, Sizes A through F.

1. Manufacturers:

(a) Josam Co.

(b) Smith, Jay R. Mfg. Co.

(c) Tyler Pipe; Wade Div.

(d) Zurn Industries, Inc.; Specification Drainage Operation.

B. Water Hammer Arresters: ASSE 1010 or PDI-WH 201, piston type with pressurized metal-tube cushioning chamber. Sizes indicated are based on ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

1. Available Manufacturers:

(a) Amtrol, Inc.

(b) Josam Co.

(c) Precision Plumbing Products, Inc.

(d) Sioux Chief Manufacturing Co., Inc.

(e) Watts Industries, Inc.; Drainage Products Div.

(f) Watts Industries, Inc.; Water Products Div.

(g) Zurn Industries, Inc.; Wilkins Div.

C. Hose Bibbs: Bronze body with replaceable seat disc complying with ASME A112.18.1M for compression-type faucets. Include NPS 1/2 or NPS 3/4 (DN 15 or DN 20) threaded or solder-joint inlet, of design suitable for pressure of at least 125 psig (860 kPa); integral [or field-installed,] nonremovable, drainable hose-connection vacuum breaker; and garden-hose threads complying with ASME B1.20.7 on outlet.

1. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.

2. Finish for Service Areas: Chrome or nickel plated.

3. Finish for Finished Rooms: Chrome or nickel plated.

4. Operation for Equipment Rooms: Wheel handle or operating key.

5. Operation for Service Areas: Wheel handle.

6. Operation for Finished Rooms: Operating key.

7. Include operating key with each operating-key hose bibb.

8. Include integral wall flange with each chrome- or nickel-plated hose bibb.

D. Air Vents: Float type for automatic air venting.

1. Bolted Construction: Bronze body with replaceable, corrosion-resistant metal float and stainless-steel mechanism and seat; threaded NPS 1/2 (DN 15) minimum inlet; 125-psig (860-kPa) minimum pressure rating at 140 deg F (60 deg C); and threaded vent outlet.

2. Welded Construction: Stainless-steel body with corrosion-resistant metal float, stainless-steel mechanism and seat, threaded NPS 3/8 (DN 10) minimum inlet, 150-psig (1035-kPa) minimum pressure rating, and threaded vent outlet.

E. Roof Flashing Assemblies: Manufactured assembly made of[**6-lb/sq. ft. (30-kg/sq. m), 0.0938-inch- (2.4-mm-)**] thick, lead flashing collar and skirt extending at least **[10 inches (250 mm)**] from pipe with galvanized steel boot reinforcement, and counterflashing fitting.

1. Manufacturer:

   (a) Acorn Engineering Company; Elmdor/Stoneman Div.

2. Open-Top Vent Cap: Without cap.

3. Low-Silhouette Vent Cap: With vandal-proof vent cap.

4. Extended Vent Cap: With field-installed, vandal-proof vent cap.

F. Open Drains: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting, joined with ASTM C 564, rubber gaskets.

G. Deep-Seal Traps: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap seal primer valve connection.

1. NPS 2 (DN 50): 4-inch- (100-mm-) minimum water seal.

2. NPS 2-1/2 (DN 65) and Larger: 5-inch- (125-mm-) minimum water seal.

H. Floor-Drain Inlet Fittings: Cast iron, with threaded inlet and threaded or spigot outlet, and trap seal primer valve connection.

I. Fixed Air-Gap Fittings: Manufactured cast-iron or bronze drainage fitting with semiopen top with threads or device to secure drainage inlet piping in top and bottom spigot or threaded outlet larger than top inlet. Include design complying with ASME A112.1.2 that will provide fixed air gap between installed inlet and outlet piping.

J. Stack Flashing Fittings: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.

K. Vent Caps: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and set-screws to secure to vent pipe.

L. Vent Terminals: Commercially manufactured, shop- or field-fabricated, frost-proof assembly constructed of galvanized steel, copper, or lead-coated copper. Size to provide 1-inch (25-mm) enclosed air space between outside of pipe and inside of flashing collar extension, with counterflashing.

M. Downspout Boots: ASTM A 48 (ASTM A 48M), gray-iron casting, with NPS 4 (DN 100) outlet; shop-applied bituminous coating; and inlet size to match downspout.

N. Downspout Boots: ASTM A 74, Service class, hub-and-spigot, cast-iron soil pipe.

O. Conductor Nozzles: Bronze body with threaded inlet for connected conductor size, and bronze wall flange with mounting holes.

1. Finish: [**Polished**] [**Nickel**] bronze.

2.13 SLEEVE PENETRATION SYSTEMS

A. Manufacturer:

1. ProSet Systems, Inc.

B. Description: UL 1479, through-penetration firestop assembly consisting of sleeve and stack fitting with firestopping plug.

1. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.

2. Stack Fitting: ASTM A 48 (ASTM A 48M), gray-iron, hubless-pattern, wye-branch stack fitting with neoprene O-ring at base and gray-iron plug in thermal-release harness in branch. Include PVC protective cap for plug.

(a) Special Coating: Include corrosion-resistant interior coating on fittings for plastic chemical waste and vent stacks.

2.14 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:

1. General Use: 4-lb/sq. ft. (20-kg/sq. m), 0.0625-inch (1.6-mm) thickness.

2. Vent Pipe Flashing: 3-lb/sq. ft. (15-kg/sq. m), 0.0469-inch (1.2-mm) thickness.

3. Burning: 6-lb/sq. ft. (30-kg/sq. m), 0.0938-inch (2.4-mm) thickness.

B. Copper Sheet: ASTM B 152 (ASTM B 152M), of the following minimum weights and thicknesses, unless otherwise indicated:

1. General Applications: 12 oz./sq. ft. (3.7 kg/sq. m or 0.41-mm thickness).

2. Vent Pipe Flashing: 8 oz./sq. ft. (2.5 kg/sq. m or 0.27-mm thickness).

C. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch (1.01-mm) minimum thickness, unless otherwise indicated. Include G90 (Z275) hot-dip galvanized, mill-phosphatized finish for painting if indicated.

D. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil (1.01-mm) minimum thickness.

E. Fasteners: Metal compatible with material and substrate being fastened.

F. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

G. Solder: ASTM B 32, lead-free alloy.

H. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

2.15 CLEANOUTS

A. Cleanouts: Comply with ASME A112.36.2M and ASME A112.3.1.

1. Application: Floor cleanout, wall cleanout and for installation in exposed piping.

2. Manufacturers:

(a) Josam Co.;

(b) Josam Co., Blucher-Josam Div.

(c) Smith, Jay R. Mfg. Co.;

(d) Tyler Pipe, Wade Div.;

(e) Watts Industries, Inc., Drainage Products Div.;

(f) Zurn Industries, Inc., Jonespec Div.;

(g) Zurn Industries, Inc., Specification Drainage Operation;

3. Body or Ferrule Material: [**Cast iron**].

4. Clamping Device: As required.

5. Outlet Connection: Threaded, inside calk or spigot.

6. Closure: Brass plug with straight threads and gasket.

7. Adjustable Housing Material: Cast iron with threads, set-screws or other device.

8. Frame and Cover Material and Finish: Nickel-bronze, copper, polished bronze or stainless steel.

9. Frame and Cover Shape: Round.

10. Top Loading Classification: Light Duty, medium Duty, heavy Duty, extra Heavy-Duty or special Duty.

2.16 FLOOR, ROOF, TRENCH, DRAINS (SEE SCHEDULE ON DRAWINGS)

A. Floor, Roof, Trench, Drains: Comply with ASME A112.21.1M and ASME A112.21.1M with ASME A112.14.1, backwater valve, ASME A112.3.1.

1. Application: Area drain, Floor drain, Funnel floor drain, etc.

2. Manufacturers:

(a) Josam Co., Blucher-Josam Div.;

(b) Smith, Jay R. Mfg. Co.;

(c) Tyler Pipe, Wade Div.;

(d) Watts Industries, Inc., Drainage Products Div.;

(e) Zurn Industries, Inc., Jonespec Div.;

(f) Zurn Industries, Inc., Specification Drainage Operation;

2.17 GREASE INTERCEPTORS (SEE DESCRIPTION ON DRAWINGS)

2.18 SOLIDS INTERCEPTORS

A. Solids Interceptors:

1. Manufacturers:

(a) Josam Co.;

(b) MIFAB Manufacturing, Inc.;

(c) Rockford Sanitary Systems, Inc.;

(d) Schier Products Co.;

(e) Smith, Jay R. Mfg. Co.;

(f) Town & Country Plastics, Inc.;

(g) Tyler Pipe, Wade Div.;

(h) Watts Industries, Inc., Drainage Products Div.;
(i) Zurn Industries, Inc., Specification Drainage Operation;

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 15 Section 15051 "Basic Plumbing Materials and Methods" for piping joining materials, joint construction, and basic installation requirements.

B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.

2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.

3. Do not install bypass piping around backflow preventers.

C. Install pressure regulators with inlet and outlet shutoff valves and balance valve bypass. Install pressure gages on inlet and outlet.

D. Install strainers on supply side of each control valve, pressure regulator, and solenoid valve.

E. Install draining-type ground or ground post hydrants with 1 cu. yd. (0.75 cu. m) of crushed gravel around drain hole.

1. Set ground hydrants with box flush with grade.

2. Set post hydrants in concrete paving or in 1 cu. ft. (0.03 cu. m) of concrete block at grade.

F. Install trap seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

G. Install expansion joints on vertical risers, stacks, and conductors if indicated.

H. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet (15 m).
4. Locate at base of each vertical soil and waste stack.

I. Install cleanout deck plates with top flush with finished floor, for floor cleanouts for piping below floors.

J. Install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall, for cleanouts located in concealed piping.

K. Install flashing flange and clamping device with each stack and cleanout passing through floors with waterproof membrane.

L. Install vent flashing sleeves on stacks passing through roof. Secure over stack flashing according to manufacturer's written instructions.

M. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch (25-mm) clearance between vent pipe and roof substrate.

N. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
3. Set with grates depressed according to the following drainage area radii:

   (a) Radius, 30 Inches (750 mm) or Less: Equivalent to 1 percent slope, but not less than 1/4-inch (6.35-mm) total depression.

   (b) Radius, 30 to 60 Inches (750 to 1500 mm): Equivalent to 1 percent slope.

   (c) Radius, 60 Inches (1500 mm) or Larger: Equivalent to 1 percent slope, but not greater than 1-inch (25-mm) total depression.

4. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.

5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

O. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.

1. Install roof-drain flashing collar or flange so no leakage occurs between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.

2. Position roof drains for easy access and maintenance.

P. Install interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.

1. Above-Floor Installation: Set unit with bottom resting on floor, unless otherwise indicated.

2. Flush with Floor Installation: Set unit and extension, if required, with cover flush with finished floor.

3. Recessed Floor Installation: Set unit in receiver housing having bottom or cradle supports, with receiver housing cover flush with finished floor.

4. Install cleanout immediately downstream from interceptors not having integral cleanout on outlet.

5. Coordinate oil-interceptor storage tank and gravity drain with Division 2 Section "Fuel-Oil Distribution."

Q. Install grease recovery units on floor. Install trap, vent, and flow-control fitting according to authorities having jurisdiction.

1. Install control panel adjacent to unit, unless otherwise indicated.

R. Fasten wall-hanging plumbing specialties securely to supports attached to building substrate if supports are specified and to building wall construction if no support is indicated.

S. Fasten recessed-type plumbing specialties to reinforcement built into walls.

T. Install wood-blocking reinforcement for wall-mounting and recessed-type plumbing specialties.

U. Install individual shutoff valve in each water supply to plumbing specialties. Use ball, gate, or globe valve if specific valve is not indicated. Install shutoff valves in accessible locations. Refer to Division 15 Section "Plumbing - Valves" for general-duty ball, butterfly, check, gate, and globe valves.

V. Install air vents at piping high points. Include ball, gate, or globe valve in inlet and drain piping from outlet to floor drain.

W. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

X. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Connect plumbing specialties to piping specified in other Division 15 Sections.

D. Ground equipment.

E. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

F. Connect plumbing specialties and devices that require power according to Division 16 Sections.

G. Interceptor Connections: Connect piping, flow-control fittings, and accessories.

1. Grease Interceptors: Connect inlet and outlet to unit, and flow-control fitting and vent to unit inlet piping. Install valve on outlet of automatic drawoff-type unit.

2. Grease Recovery Units: Connect inlet, outlet, and vent piping; controls; electric power; and factory-furnished accessories to unit.

3. Oil Interceptors: Connect inlet, outlet, vent, and gravity drawoff piping to unit; flow-control fitting and vent to unit inlet piping; and gravity drawoff and suction piping to oil storage tank.

4. Solids Interceptors: Connect inlet and outlet.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of lead sheets 6-lb/sq. ft. (30-kg/sq. m), 0.0938-inch (2.4-mm) thickness or thicker. Solder joints of lead sheets 4-lb/sq. ft. (20-kg/sq. m), 0.0625-inch (1.6-mm) thickness or thinner.

2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches (250 mm), and skirt or flange extending at least 8 inches (200 mm) around pipe.

2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 7 Section "Sheet Metal Flashing and Trim."

F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each piece of equipment.

1. Text: Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.

2. Refer to Division 15 Sections "Basic Plumbing Materials and Methods” and “Plumbing - Identification" for nameplates and signs.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled grease recovery units and their installation, including piping and electrical connections. Report results in writing.

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain each piece of equipment. Refer to Division 1 Sections "Closeout Procedures” and/or “Demonstration and Training."

END OF SECTION 15430

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. All work associated with piping systems.

1.2 RELATED DOCUMENTS

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

B. Section. 15010 - Basic Mechanical Requirements.

C. Section. 15050 - Basic Mechanical Materials and Methods. (Mechanical)

D. This section is a part of each Division 15000 Section.

E. Section 09900 - Painting

1.3 REFERENCES

A. ANSI/ASME B31.9 Building Services Piping.

1.4 QUALITY ASSURANCE

A. Installer. Company specializing in piping systems with five years minimum experience.

1.5 SUBMITTALS

A. Submit product data under provisions of Section 01300.

B. Include product description, list of materials for each service, and locations.

C. Submit manufacturers installation instructions under provision of Section 01300.

PART 2 - PRODUCTS

2.1 MATERIALS FOR PIPE AND FITTINGS

A. Pipe and fittings shall be fabricated per the following schedule:

SERVICE	SIZE	PIPE	FITTINGS
L.P. Steam (below 15 psi)	2-1/2" and under	Schedule 40, Seamless or ERW, ASTM-A53, Grade B	Malleable iron 150 lbs; cast iron 125 lbs; screwed or socket weld
See note	3"-10"	Schedule 40, Seamless or ERW	Schedule 40 weld end (butt weld)
	12"-24"	Standard weight (.375" wall) ASTM S-53, Seamless or ERW	Std. Wt. (.375" wall) welded (butt weld)
L.P. condensate return, drips and pumped discharge	2-1/2" and under	Sch. 80, Seamless	Iron class 150 lb. screwed or socket weld
	3"-10"	Sch. 40, Seamless	Sch. 40 weld end (butt weld)
	12"-24"	Std wt. (.375"wall), Seamless	St. wt. (.375" wall) weld end (butt weld)
Closed condenser, chilled, hot water, dual temp., and secondary water (up to 300 psi) - mains, risers, vents and reliefs	3" and under	Schedule 40 ASTM-A53, Grade B, Seamless or ERW	150 psi and under, malleable iron 150 lb., screwed 151 psi-300 psi: Malleable iron 300 lb. screwed
	3"-10"	Schedule 40, Seamless or ERW	Sch. 40 weld end
	12"-24"	Standard weight (.375" wall) , Seamless or ERW	Std. Wt. (.375: wall) weld end
Secondary water branches risers to shut-off valves	3" and under	Schedule 80, Seamless or ERW from main/risers to valves to units/equipment	150 psi and under: Malleable iron 150 lb. screwed 151 psi – 300 psi: Malleable iron 300 lb screwed
	3"-10"	Schedule 80, Seamless or ERW	Sch. 80 weld end
	4" and under	OPTION: (from valves to units – equipment): copper type 'L' hard ASTM-B88 drawn, provide – dielectric fitting between steel/valve and copper pipe	Wrought or copper, brazed (B cup-5) ASTM-B32, ANSI B16.22
	12"-145:	Standard weight (.375" wall) , Seamless or ERW	St. wt. (.375" wall) weld end

SERVICE	SIZE	PIPE	FITTINGS
Drain Pan Piping See Note 2	4" and under	Copper Type L hard drawn	Wrought or copper with lead free 95/5 solder or brazed
Domestic Water	3" and under	Copper Type L hard drawn	Wrought or copper with lead free 95/5 solder or brazed.
Vents and Reliefs		Same materials as pipe systems they serve	Same material and fittings as systems they serve.
High Temperature Hot Water	3" and under	Schedule 80 ASTM A-106 Grade B seamless	Malleable iron, 300 lb. class screwed or socket weld 300 lbs.
	3"-10"	Schedule 40, Seamless	Sch. 40 weld end (butt weld)
	12"-24"	Standard weight (.375" wall) Seamless	Std. Wt. (.375" wall) weld end (butt weld)
Fuel Oil Piping See “Fuel Oil Systems”			
Refrigerant Piping See “Section 15530"			
MRI Vent Piping		Aluminum piping (0.500 in wall thickness)	

NOTES

1. Unless specified otherwise, all steel piping shall be Type ASTM-A-53 Grade B seamless or ERW. Furnace butt weld pipe is not acceptable. All pipe shall be of the domestic manufacture, delivered to the job properly primed and marked and supplied with the interior surfaces clean and rust free. Each end shall be capped to avoid the rusting of the interior surface. Piping found to be in violation of this specification may be required to be removed from the job site whether or not already installed. Mill certifications from the pipe supplier shall be made available upon request.

2. All copper tubing shall be not less than 99.9 percent pure copper, as manufactured by Revere Copper and Brass Co., Chase Brass and Copper Co., Inc. Bridgeport Brass Co., or other approved. Wherever possible, tubing shall be continuous with couplings up to 20 feet in length. Tubing shall conform to ASTM B88.

3. ASME B31.1 Power Piping Code shall apply for all steam condensate systems over 150 psi @ 366°F (and or Local Jurisdictional Codes) and for high temperature hot water systems above 160 psi and 250°F.

   B. Piping specifications shall be submitted with shop drawings.

C. All pipe fittings shall be of domestic manufacture in conformance with the following codes:

Cast iron fittings	ANSI B16.4
Malleable iron fittings	ANSI B16-3
Weld end fittings	ANSI B16-9, ASTM A-234
Socket weld fittings	ANSI B16.11
Copper fittings	ASTM B-32, ANSI B16.22
Welded flanges	ASTM-A105; ANSI B16.5
Cast copper	B16.18
Threaded Flanges	
Cast Iron	ANSI B16.1
Malleable Iron	ASTM A197
Malleable Iron Unions	ASME B16.39

D. Open condenser water systems are defined as systems in which the atmosphere is in direct contact with water in piping system via an open cooling tower.

E. Galvanized steel pipe shall be hot dipped galvanized of Republic Steel Corporation, National Tube Co., Youngstown, or other approved manufacturer.

F. Secondary water branches shall be shop fabricated. Steel branches shall be shop fabricated complete with valve and accessory fittings and suitable for welding to risers without further work. Copper branches similarly shall be shop fabricated with all accessories suitable for ready attachment to unit and steel branches. Provide a dielectric fitting between steel and copper pipe (a brass valve is not a substitute for a dielectric fitting).

G. On 3" piping systems, the contractor shall have the option of using either screwed or weld end fittings unless otherwise noted in the Contract Documents, directed and/or compliance to local jurisdictional codes or authorities.

2.2 VALVES

A. Furnish and install valves shown on the drawings, specified herein and/or necessary for the control and easy maintenance of all piping and equipment. All valves shall be first quality of approved manufacture, shall have proper clearances, and shall be tight at the specified test pressure. Each valve shall have the maker's name or brand, the figure or list number and guaranteed ANSI working pressure cast on the body and cast or stamped on the bonnet, or shall be provided with other means of easy identification. All valves of one type (gate, ball, butterfly) shall be the product of one manufacturer for that type of valve.

B. Valves shall be a minimum working pressure and materials as fittings specified for the service except as herein modified. All gate and globe valves shall be suitable for repacking under pressure. Regardless of service, valves shall not be designated for less than 125 pounds per square inch steam working pressure.

C. It is the intention to use ball and butterfly valves for shut-off wherever possible. Gate valves shall be used for steam systems where ball and butterfly valves may not be practical by pressure/temperature or local authority having jurisdiction.

D. The following chart designates valve categories for shut-off valves:

SHUT OFF VALVE SCHEDULE

	CATEGORY	SIZE	TYPE	MFG. AS STD.	FIG. #	RATING
V-1	Up to 150 psi CW, CHW, HW	2 ½" & down 3" & up	Ball Butterfly	Apollo Jamesbury	70-100 815L-11-2236TT	600# WOG ANSI 150#
V-2	151-300 psi CW, CHW, HW	2/ ½" & down 3" & up	Ball Butterfly	Apollo Jamesbury	70-100 830L-11-22HMBT	600# WOG ANSI 300#
V-3	Steam & Condensate Up to 15 psi	2 ½" & down 3" & up	Ball Butterfly	Apollo Jamesbury	70-140-64 815L-11-22HBTT	250 psi STM ANSI 150#
V-4	Steam & Condensate (Non Utility Company Steam) 16 psi - 125 psi & High Temp Hot Water up to 300°F	2 ½" & down 3" & up	Ball Butterfly	Apollo Jamesbury	70-140-64 830L-11-22HBMT	250 psi ANSI 300#

NOTES:

SHUT OFF VALVE EQUIVALENT FIGURE SCHEDULE

VALVE TYPE	SERVICE	ANSI RATING	MAX. WORKING PRESSURE @ 200°F	MODEL
Ball	CW, CHW, HW		300 psi	Apollo 70-100 Milwaukee BA-100
Butterfly	CW, CHW. HW	150		Bray/McCannalock Series 41 (Lug Type) Keystone Series 372 DES (Lug Type) Winn S15L-1122 (Lug Type)

VALVE TYPE	SERVICE	ANSI RATING	MAX. WORKING PRESSURE @ 200°F	MODEL
Butterfly (See Note)	CW, CHW, HW	300		Bray/McCannalock Series 43 (Lug Type) Keystone Series 372-DES (Lug Type) Winn S30L-1122 (Lug Type)
Gate	up to 2-½" Steam		150#	Stockham Figure No. B-120 Powell Figure No. 2700 Milwaukee Figure No. 1151
	3" & up Steam		150#	Stockham Figure No. G623 Powell Figure No. 1793 Milwaukee Figure No. F-2885M
	up to 2-1/2" Steam and Utility Company Steam		300#	Stockham Figure No. B-144 Powell Figure No. 375 Milwaukee Figure No. 1182
	3" & up Steam and Utility Company Steam		300#	Stockham Figure No. F-667 Powell Figure No. 1797 Milwaukee Figure No. F-2894M

NOTES:

1. Butterfly valves shall have gear operator 8" diameter and larger for ANSI 150 valves; 6" and larger for ANSI 300 valves. Valves smaller shall have multi-position latching handle.

2. Valves 4" and larger (all valve sizes for steam over 15 psig) in equipment area which is more than 8'-0" above finished floor shall be provided with operating chains, sprockets, and guides.

3. All ball valves shall have the following options:

   a. Balancing stop for hydronic installations.

   b. 2 1/4" stem extensions on insulated piping systems.

   c. Stainless steel ball and stem, and multi-filled TFE seats for steam, condensate and high temperature hot water systems.

4. Valves for Con Edison Steam shall comply with Con Edison specifications.

5. Gate valves shall be Stockham, Powell or Milwaukee.

   a. Bronze valves 3" or smaller shall be inside screw, traveling stem, bronze wedge.

   b. Iron body valves 3" and above shall be outside screw and yoke, rising stem, bronze mounted.

6. Butterfly valves shall be high performance lug type Jamesbury, McCannalok, Grinnell Winn Series or Keystone 362/372 DES series. Valves shall be bi-directional dead end service, lug type ANSI Class 150 or 300.

   a. The face-to-face dimensions must meet AP Spec I609 MSS SP 67.

   b . Pressure vessel is to meet full ANSI ratings.

   c. Valve is to seal bi-directional dead end service at full ANSI ratings. Valve shall hold full pressure with either flanged connection removed, in either direction.

   d. Valves are to be able to take full rated differential pressure when dead-ended in either direction.

   e. Valves shall have gear operator 8" and larger for ANSI 150 valves, and 6" and larger for ANSI 300 valves. Valves smaller shall have multi-positioned latching handle.

   f. All valves shall be designed to ANSI B16.5 and B16.34.

   g. All valves to be functionally tested, to include cycling the valve and topworks, measuring seating torque and verifying leaktight performance of seat.

   h. The valve should be capable of thermal cycling over its complete pressure vessel rating.

   I. The shaft packing must be capable of sealing at 1.5 times the pressure vessel rating.

   j. The valve should be designed to convert from handle operation to automated valve operation without removing the valve from the pipeline.

   k. There must be external indication of disc position.

   l. Valve stem packing area shall be fully accessible for adjustment without removal of operator.'

   m. If manually operated, the valve must have a positively retained shaft in case there is a failure of the shaft to disc attachment.

   n. Self-lubricated bearings should be used. There will be a method of retention to prevent bearing movement.

   o. No loose parts should be used to attach the shaft to the disc. Two or more pins should be used for complete attachment.

p. A double offset shaft should be used to reduce seating torque.

q. Valves body material shall be carbon steel. Shafts shall be 17-4 PH stainless steel. Discs shall be 316 stainless steel. Stem seals shall be TFE. Seats shall be self-energizing TFE or self-energizing TFE totally encapsulating as elastomeric "O" ring. Metal springs or components shall not be used to and in seat sealing.

r. Seats shall be fully replaceable in the field.

s. Ductile iron body may be used for chilled water and condenser water service, at 150 psi max service. All other valve components shall be as specified.

E. Lubricated plug valves at pump discharges shall be Nordstrom Valves, Inc. (Rockwell), Homestead or Stockham as follows:

CATEGORY	SIZE	FIGURE NO.	RATING
Up to 150 psi operating pressure	Up to 3"	142 wrench operated (screw)	200# cwp (190° # @ 200°F)
	3"-5"	143 wrench operated (screw)	200# cwp (190# @ 200°F)
	6"-12"	1169 worm gear operated (flgd)	200# cwp (190# @ 200°F)
	14"-30"	1169 worm gear operated (flgd)	150# cwp (135# @ 200°F)
151 psi to 300 psi	1"-2"	214 wrench operated (screw)	400# cwp @ 150° @ 250F)
	2"-5"	305 wrench operated (flgd)	400# cwp @ 150° @ 250F)
	6"-12"	1489 worm gear operated (flgd)	400# cwp @ 150° @ 250F)
	16"-24"	1589 worm gear operated (flgd)	400# cwp @ 150° @ 250F) (See Note 2)

NOTES:

1. Use Figure No. 1589 for systems with operating pressures greater than 135 psi at water temperature above 150°F.

2. Use with ANSI 300# flanges.

3. For hot water systems above 200°F, use valves listed for 151-300 psi operating pressures.

4. Lubricated plug.

5. Sealed port lubrication system.

6. Provide lubrication gun and spare box of lubricant for every four (4) valves.

7. Fixed gland adjustment when valve rating is 200 lb. WOG or higher to suit actual operating pressures.

8. Equipped with adjustable stops.

9. Factory lubricated.

10. Provide chain wheel drive and operator for valves 6" and larger that are located 96" or higher above floor.

F. Equivalent Lubricated Plug Valves

PSI	SIZE	MFG	FIGURE NO.	OPERATION
Up to 150 psi	Up to 3"	Walworth Homestead	1796 (screw) 611 (screw)	Wrench Wrench
	3" to 5"	Walworth Homstead	1797F (flange) 612	Wrench Wrench
	6" to 12"	Walworth Homestead	1707 612G	Worm Gear Operation Worm Gear Operation
	14"to 24"	Walworth Homestead	1703F 6129	Worm Gear Operation 175 CWP Worm Gear 150 CWP
151 to 300 psi	Up to 3"	Walworth Homestead	3412 702	Wrench ANSI 300
	6"-12"	Walworth Homestead	3622 721G	Worm Gear ANSI 300 Worm Gear Operation
	14"-24"	Walworth	3622	Worm Gear Operation

G. Check valves other than multiport check valves at pumps shall be Stockham, Powell or approved equal. Bronze screwed for 2-1/2" and down with regrinding bronze disc and iron body above 3" with regrind - renew bronze disc, and seat ring with bolted cover. Pressure ratings equal or greater than ratings of shutoff valves scheduled.

Category	Size	MFG	Figure No.	Rating
V-1	Up to 2-1/2"	Powell Stockham Milwaukee	578 B321 509	Up to 150 PSI operating pressure
	3"	Powell Stockham Milwaukee	559 G-931 F-2974M	
V-2	Up to 2-1/2"	Powell Stockham Milwaukee	560-1 B-345 508	151 to 300 PSI
	3" and larger	Powell Stockham Milwaukee	576 F-947 F-2970	

H. Multiport check valves at pump discharge shall be semi-steel installed at pump discharge as follows:

Cat.	Size	MFG	Figure No.	Rating
V-1	Up to 3"	Mueller	101 MAP Wafer	125# ANSI (175@100ºF)
	4" and larger	Mueller	105 MAP Globe Type	125# ANSI (200#@150ºF)
V-2	Up to 3"	Mueller	103 MAP Standard Wafer	250#ANSI (500#@150ºF)
	4" and over	Mueller	M 107 MAP Globe Type	250# ANSI (500#@100ºF)

NOTE

1. For system pressures over 250 psi use 300# ANSI from 14" to 24" bronze body (300# PSI at 150°F).

I. Balancing Valves:

1. Balancing valves shall be ball type for 2-1/2" and down, lubricated plug valves for above 3", and shall be full line size. At cooling towers use butterfly valves.

2. Furnish and install in the return line from each piece of hydronic equipment (cabinet heaters, unit ventilators, unit heaters, fin tube, water coil, hydronic terminal equipment, etc.) a one piece, non-ferrous union type bronze/brass flow measuring and Balancing/shut-off valve combination. The flow element shall be a low loss/high signal Venturi type (± 2% accuracy) of one to ten rangeability, equipped with dual Pete's plug test ports for temperature, pressure and flow measurement. Balancing/shut off valves shall be ball type with large diameter plated ball, teflon seats, blow out proof stem with

teflon packing and packing nut, full size handle with grip and memory stop. Entire assembly shall be rated to working pressures described in previous section of this specification.

J. Miscellaneous Notes:

1. Furnish valve tags as described elsewhere.

2. All radiators, hydronic equipment, etc., shall be individually valved on supply and return.

3. Furnish a portable meter complete with all accessories for measuring flows.

4. Furnish to the Owner, 6 sets of thermometers and pressure gauges.

5. On branch piping from hydronic main distribution piping (branch piping is defined as any piping from either main distribution piping that serves more than one piece of hydronic equipment) or branch piping form main distribution piping to vertical risers, provide an isolation valve on supply line and combination balancing and shut-off valve on return line.

6. Globe valves be of equivalent pressure ratings and manufacturer to that stated for gate valves.

7. Chilled water piping connections to air conditioning units shall include all necessary gate valves, air vent valves, drain connections and automatic valves.

8. Inverted ball float traps shall be used for venting water mains. Provide shut-off valve and strainer ahead of same.

9. Compression type, key operated air cocks shall be furnished and installed where required for additional venting. Cocks shall be 1/4" in size and shall be all bronze construction, at least two dozen keys shall be delivered to the Owner's representative for operating these cocks.

10. Drain cocks with threaded ends for hose connection shall be provided for any low points in the risers.

2.3 STRAINERS

A. There shall be approved strainers in the inlet connections to each bucket or combination float and thermostatic steam trap, each water feeder and make-up connection, each water regulating valve, each pump, each vent, and each diaphragm valve. The intention is to protect by strainers, all apparatus of an automatic character whose proper functioning would be interfered with by dirt on that seat, or by scoring of the seat. Strainers shall be Sarco or approved.

B. All strainers in waterlines (including all pump inlets) and 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.

C. All strainers shall have cast iron, semi-steel or bronze bodies equivalent to ratings specified in "valves" 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.

D. Strainer screen perforations shall be 1/32" for steam and mixture of steam and condensate. Water 1/16" perforations for sizes up to 3"; 1/8" perforations for sizes 4" to 12".

E. Provide approved valved and capped dirt blow off connections for each strainer 1-1/2" and larger, with the valve located 6" to 1'-0" below strainer or as directed.

F. Nipples and valves to be full size of strainer blow off tapping. Strainers 1¼" and smaller to have capped nipples at least 6" long. For all strainers, the blow out connection is to terminate in an approved manner, at a point where there will be no risk of flooding or damage.

G. All strainers shall be provided with flanged covers for screen removal in lieu of screwed covers for screen removal wherever obtainable.

H. All strainer screens 8" and above shall be reinforced for the operating conditions.

2.4 EXPANSION JOINTS & LOOPS

A. All piping shall be installed in such a manner as to allow for expansion and contraction by means of offsets, pipe loops or expansion joints without causing undue stress in piping or at connections to equipment. Where pipe offsets or loops are not detailed or dimensioned on drawings, the contractor is to submit calculations to show that the stress range of the pipe does not exceed 15000 psi.

B. Expansion joints shall be the type, manufacturer and model number as indicated on drawings. Where no type or model number is indicated, any of the expansion joints described below may be used if they are suitable for design and operating conditions of temperature pressure and movement except that Bellow Expansion Joints and Expansion Compensators shall not be used for (a) steam with pressures over 15 psig for all sizes or (b) hydronic systems operating over 200 psig operating pressure in all sizes.

C. All expansion joints shall be designed so that pressure containing components are in accordance with requirements as specified in ANSI B-31.1 Power Piping.

D. All expansion joints and expansion compensators shall have a metal nameplate permanently attached bearing inscription of size, type, pressure rating, allowable movement, year of fabrication and manufacturers identification number.

E. All pipe lines containing expansion joints shall be guided in accordance with expansion joint manufacturers instructions as substantiated by data in manufacturers catalog or separate date furnished with submittal drawings.

F. Contractor, in conjunction with information provided by expansion joint manufacturer is to submit anchor load calculations for both operating and hydrostatic test conditions.

G. Packed Slip Expansion Joints:

1. Packed slip expansion joints shall be weld end type designed for the injection of semi-plastic packing under full line pressure and shall be the manufacturer and model number indicated on drawings incorporating following:

(a) Sliding slip shall be constructed of A53 Gr B seamless pipe - schedule 80 for sizes to 16" inclusive and schedule 60 for sizes 18" to 24" and shall incorporate stainless steel stops welded in place to prevent disengagement of slip in event of anchor failure. Slip shall be dual chrome plated with a minimum of 1 mil hard chrome over 1 mil of crack free hard chrome. Plating thickness shall be verified by Permascope inspection in accordance with ASTM Standard B-499 and certification shall be furnished with expansion joint.

(b) Traverse chamber shall be seamless A-53 Grade B pipe or equivalent tubing with butt type circumferential welds only and shall be furnished with non-metallic flexible bronze filled teflon internal and external guides to prevent scoring or binding of sliding slip.

(c) Stuffing box shall be designed to provide an area of packing in contact with the sliding slip at least 15 times the nominal pipe diameter and shall incorporate one (1) packing cylinder for 1-1/2" thru 4" size and one (1) additional cylinder for each 3" of nominal pipe diameter. Packing cylinders shall be welded in place, be a minimum 2" diameter with internal acme threads with a discharge tip having a check valve effect to prevent blow back and permit adding packing under full line pressure and furnished with a matching plunger having a minimum 3/4" diameter tip. Expansion joints operating over 200 psig shall be furnished with packing cylinders having an integral stainless steel plug type safety valve for positive blow back protection.

(d) Stuffing box shall be packed with a combination of self lubricating teflon/graphite braided packing and flake Grafoil injectable packing. Teflon-asbestos and teflon semi-plastic injectable packings are not acceptable and shall not be used.

(e) Each expansion joint shall be furnished with a minimum of two (2) plugs of spare flake Grafoil semiplastic injectable packing for each packing cylinder. For system operating over 200 psig where expansion joints are furnished with packing cylinders having an integral stainless steel plug type safety valve, a tools shall be furnished to safely remove under full line pressure the impacted packing between safety valve and discharge tip. Where project contains more than one (1) expansion joint operating above 200 psig, a minimum of one (1) such tools shall be furnished for every five (5) expansion joints operating above 200 psig.

(f) Expansion joints shall be as manufactured by Advanced Thermal Systems and shall be Type TP2W GBZ for 150 psig design condition and TP2W-131-150 GBBZ with Style GB Saf-T-Packer for over 150 psig design conditions. For expansion joints operating below 200°F, Style 200G packing with rubber and fiberglas sealing rings shall be used in lieu of Style 150 packing. Expansion joints as manufactured by Adsco and Yarway will be approved if they conform to all features specified above.

(g) Packed joints used for steam over 15 psig shall be 100% radiographed at factory.

2. Expansion joints shall be designed to accommodate an amount of traverse as shown in expansion joint designation as indicated on drawings or a total traverse greater than the combined extension and compression that must be accommodated after the expansion joint is installed including allowance for frame shortening in buildings with concrete columns. Submittal drawings are to indicate amount of factory precompression as well as available movement in compression and extension from the installed position.

H. Packed Flexible Ball Joints:

1. Packed flexible ball joints shall be weld and type designed for injection of semi-plastic packing under full line pressure and shall be the manufacturer and model number indicated on drawings incorporating the features indicated below:

(a) Ball sphere shall be dual chrome plated with a minimum of 1 mil hard chrome over 1 mil of crack free hard chrome. Plating thickness shall be verified by Permascope inspection in accordance with ASTM Standard B-499 and certification shall be furnished with expansion joint.

(b) Ball socket shall be one piece with integral socket/retainer to eliminate the need for threaded caps or bolted retainer flanges.

(c) Ball socket shall incorporate packing cylinders in quantities as indicated below. Packing cylinder shall be welded in place, be a minimum of 2" in diameter with internal acme threads with a discharge tip having a check valve effect to prevent blow back and permit adding packing under full line pressure all furnished with a matching plunger having a 3/4" diameter tip. Expansion joints operating over 200 psig shall be furnished with packing cylinders having an integral stainless steel plug type safety valve for positive blow back protection.

Ball Joint Size	Qty. Parking Cylinders
3/4" to 4"	1

Ball Joint Size	Qty. Parking Cylinders
5" & 6"	2
8" & 10"	3
12" to 18"	4
18" to 20"	6
24"	8
30"	12

(d) Stuffing box shall contain compression seals of ductile iron, teflon-graphite containment seals and flake Grafoil injectable packing. Teflon-asbestos and teflon semi-plastic injectable packings are not acceptable and shall not be used.

(e) Each expansion joint shall be furnished with a minimum of two (2) plugs of spare flacke Grafoil semiplastic injectable packing for each packing cylinder. For system operating over 200 psig where expansion joints are furnished with packing cylinders having an integral stainless steel plug type safety valve, a tools shall be furnished to safely remove under full line pressure the impacted packing between safety valve and discharge tip. Where project contains more than one (1) expansion joint operating above 200 psig, a minimum of one (1) such tools shall be furnished for every five (5) expansion joints operating above 200 psig.

(f) Expansion joints shall be as manufactured by Advanced Thermal Systems and shall be Type P2-SWW up to 150 psig or Type P2-SWW-150G-70-20B with Style GB Saf-T-Packer for systems operating above 150 psig. Packed flexible ball joint manufacturer to submit calculations verifying that length of spool piece between ball joints is ample to properly accommodate expansion and contracting including allowance for frame shortening in buildings with concrete columns.

2. Packed flexible ball joint manufacturer to submit calculations verifying that length of spool piece between ball joints is ample to properly accommodate expansion and contraction including allowance for frame shortening in buildings with concrete columns.

I. Bellows Expansion Joints and Expansion Compensators:

1. Bellow expansion joints and expansion compensators shall be the type, manufacturer and model number indicated on drawings and shall incorporate the following:

(a) Expansion joints in sizes 3" and over shall consist of Inconel 600 bellows formed from seamless tubing or tubing with longitudinal seam weld no greater than 10% thicker than parent material with flanged ends suitable for operating pressure and temperature.

(b) Bellows elements 3" and over may be externally pressurized or internally pressurized with supplemental reinforcing by means of external rings, if necessary. Internally pressurized bellows with three (3) or more corrugations shall be furnished with internal sleeves or liners. Bellows elements shall be designed in accordance with standards of the Expansion Joint Manufacturers Association (EJMA) for 7000 full cycles, unless otherwise indicated and calculations in accordance with EJMA standards are to be furnished with submitted drawings.

(c) Expansion joints in sizes 2-1/2" or less shall be "Expansion Compensator" type with externally pressurized bellows. For use with steel pipe, bellows shall be Inconel 600 and casing and threaded nipple ends shall be carbon steel. For use with bronze pipe or copper tubing, compensator casing and bellows shall be all bronze construction with threaded or sweat type ends. Expansion compensators shall be capable of accommodating 1-3/4" compression and 1/4" extension and shall be so placed in system that movements do not exceed these limits.

2. Expansion joints shall be designed to accommodate an amount of traverse greater than the combined extension and compression that must be accommodated after the expansion joint is installed including allowance for frame shortening in building with concrete columns. Submittal drawings are to indicate amount of factory precompression as well as available movement in compression and extension from installed position.

2.5 HANGERS, SUPPORTS, ANCHORS, AND GUIDES

A. See "Seismic Design" and comply as follows:

1. See "Foundations, Vibration Isolation, and Supports for Rigidly Supported Equipment (Seismic Design)."

2. As noted in "Seismic Design", the HVAC contractor shall engage the services of a professional engineer with experience in the field of equipment support and seismic restraints (or an approved piping expert who has specialized in piping design). The Engineer shall select and coordinate the restraints and supports based on the final coordinated drawings showing exact location of piping and equipment and shall coordinate with the structural engineer to ascertain that the connections to the structure will resist the horizontal forces to which they might be subjected. He shall submit details and calculations as required to demonstrate compliance.

3. Seismic Restraints shall be installed to restrain and protect piping in the event of an earthquake and shall be installed in addition to pipe hangers, brackets and supports. Seismic Restraints shall not be used in lieu of regular hangers and supports as are otherwise required to support the piping.

4. Anchors shall be designed to accommodate seismic forces plus any forces imposed by expansion joints or pipe bends and loops. Loads and details of

attachment to structure shall be submitted to structural engineer for coordination and approval.

B. In all cases, attachments to structure shall be approved by the Structural Engineer. Loads and details of attachment to structure shall be submitted to structural engineer for coordination and approval.

C. All required supports, hangers, anchors, and guides shall be provided and installed by this contractor. Shop drawings shall be submitted indicating the following.

1. Riser anchors shall not be fixed to building until floors are poured, due to possible settling.

2. Methods of hanging or supporting all mechanical equipment & piping furnished by this trade.

3. Insert locations intended for the hanging of any mechanical equipment shall note the weight to be hung from each insert.

4. Insert locations intended for the hanging of piping over 5" or equipment shall also note the weight to be hung from each typical insert.

5. Where other methods are used, beam clamps or fish plates, for example, weights shall be similarly shown.

6. Multiple piping whether by other trades or not, if included on a trapeze type hanger furnished by this trade shall similarly indicate weights.

7. Note that mechanical equipment is not limited to pipe connected equipment, but includes fans, coils, etc.

8. Although piping under 6" need not be shown, furnish information upon request at any time during the course of the installation.

9. The indication of weights will not be waived unless there is reason to accept a general statement, approved in writing by the Architect and/or the Structural Engineer.

10. The structural engineer must approve the method of hanging before work is commenced.

D. All pipe supports shall be of type and arrangement as shown on "Pipe Hanger and Support Schedule" on drawings and hereinafter specified. They shall be so arranged as to prevent excessive deflection and avoid excessive bending stresses between supports.

E. All bracket clamp and rod sizes indicated in this specification are minimum sizes only. This trade shall be responsible for structural integrity of all supports. All structural hanging materials except variable spring units shall have a safety factor of 5 built in.

Pipe Hanger Schedule			
	C&P	F&M	Grinnell
Beam Clamp	268	282	--
Clevis Hanger	100	239	260
Clevis Roller Hanger	140	272	181
Welded Steel Bracket	84	151 or 155	195 or 199
Welded Beam Attachment	113A	–	66
Insert	266	–	280
Continuous Slotted Insert	1480	190	--
Metal Deck Ceiling Bolt	143		

F. Pipe supports shall be of the following type and figure number, as manufactured by C & P, F & M, Grinnell or as approved, and as hereinafter indicated:

Pipe Hanger Schedule			
	C&P	F&M	Grinnell
180 Shield	265P	–	–
Beam Clamp	268	282	--
Clevis Hanger	100	239	260
120 Shield	265P	80	--
Pipe Saddle	354 355 356	170 & 1700 Series	180 Series
Clevis Roller Hanger	140	272	181
Two Rod Roller Hanger	142	170	171
Rigid Trapeze	371	–	Std. 45
U-Bolt	283	176	137
C.I. Roll Stand	17	160	271
Adj. C.I. Roll Stand	53	161	274
Adj. Steel Pipe Stanchion	101	291	259
Welded Steel Bracket	84	151 or 155	195 or 199

Pipe Hanger Schedule			
Single Bolt Riser Clamp	126	241	261
Double Bolt Riser Clamp	126	–	Std. 40
Base Elbow Support	375	–	–
Double Bolt Pipe Clamp	304	261	295
Welded Beam Attachment	113A	–	66
Welded Beam Attachment W/B&N	113B	251	66
Insert	266	–	280
Continuous Slotted Insert	1480	190	--
Metal Deck Ceiling Bolt	143		

G. Anchor points as shown on drawings or as required shall be located and constructed to permit the piping system to take up its expansion and contraction freely in opposite directions away from the anchored points.

H. Guide points for expansion joints shall be located and constructed wherever required or shown on drawings and at each side of an expansion joint or loop, to permit only free axial movement in piping systems but first guides shall not be further than 3 pipe diameters on each side of joint and second guides (and subsequent guides) shall be placed no further than 17 pipe diameters along length of pipe. Guides for pipe with expansion joints shall be of the four roller heavy duty type securely welded to structural steel.

I. Guides shall be of sufficient length to contain a pipe movement 30% greater than actual pipe movement.

J. Variable spring hangers shall be located and constructed for points subject to vertical movement.

K. Maximum spacing between pipe supports, for steel pipe to prevent excessive stress: This does not apply where there are concentrated loads between supports.

Pipe Size	Max. Span/Ft.	Pipe Size	Max. Span/Ft.
1/2"	5	4"	14
3/4"	6	5"	16
1"	7	6"	17
1½	9	8"	19
2"	10	10"	22
2½”	11	12" over	23
3"	12		

L. Maximum weights on hanger rods assuming a maximum operating temperature of 450°F shall be such that stress in tension shall not exceed 9000 psi, using root area of threaded portion. In no case shall hanger size be less than 3/8" for pipe up to 2", 1/2" for pipe 2-1/2" to 3-1/2", 5/8" for pipe 4" to 5", 3/4" for pipe 6", 7/8" for pipe 8" to 12".

M. Double bolt riser clamps shall be F&S, F&M, Grinnell or approved and shall be subject to approval.

N. Back to back channel loads shall be limited to the following:

1. 3" (4.1#) channel - 2900 lbs up to 36" C To C.
2. 3" (4.1#) channel - 1700 lbs over 36" C To C.
3. 4" (5.4#) channel - 5100 lbs up to 36" C To C.
4. 4" (5.4#) channel - 3000 lbs over 36" C To C.

O. Pipe stanchion supports for horizontal pipes shall be as follows:

Run Size	**Base**
2½” to 3½	2½”
4" to 12"	3"
14" to 16"	4"
18" to 36"	6"

P. Pipe supports at the base of a vertical riser shall be pipe riser size.

Q. For copper tubing, supports shall follow schedule and specifications. Supports for uncovered lines shall be especially designed for copper tubing, and shall be of exact O.D. diameter of tubing and shall be copper plated.

R. Roller type supports shall be used for pipes subject to axial movement. They shall be braced so that movement occurs in roller rather than support rods.

S. Provide shields at hangers for cold insulated piping and saddles welded to pipe at hangers for hot insulated piping.

T. Provide all steel required for support of pipes and equipment other than steel shown on structural engineer's drawings. Submit calculations of anchor design.

U. All hangers on piping including clevis hangers, rods, inserts, clamps, stanchions, brackets, shall be dipped in Zinc Chromate Primer before installation.

V. All pipe supports shall be designed to avoid interferences with other piping, hangers, electrical conduits and supports, building structures and equipment.

W. Pipe hangers shall be connected to building structure as follows:

Building Structure Type	Pipe Support Method
Poured concrete floor slabs.	Galvanized steel inserts and/or fishplates of sufficient area to support twice the calculated dead load.
Building Structure Steel.	Beam Attachments, etc.
Precast concrete floor slabs.	Fishplates of sufficient area to support twice the calculated dead load, approved type specialty hanger accessories manufactured for the specific purpose of attaching to precast floors.
Metal deck floor slabs with concrete fill.	Galvanized steel inserts, fishplates of sufficient area to support twice the calculated dead load, approved type specialty hanger accessories manufactured for the specific purpose of attaching to metal deck floors.
Concrete slabs where piping revisions are required and approved after slabs are poured.	Piping 3" and smaller may be supported at intermediate points by “Phillips”, or other approved 3/4" expansion bolts and shields, provided main supports are welded to structural steel and such main supports are welded to structural steel and such main supports are not less than 20 feet on centers. Intermediate supports for piping 4" and larger shall be attached to concrete beams or columns by means of 4" x 4" x 3/8" thick clip knee angles with 3/4" expansion bolts in shear (horizontal) and supporting rod at 90 from anchor bolt.

2.6 THERMOSTATIC RADIATOR CONTROL VALVE

A. Provide a thermostatic radiator control valve at each perimeter heating water horizontal branch pipe and as indicated on the drawings and details.

B. The Thermostatic Radiator Control Valve shall be selected to perform accurate temperature control by preventing overheating.

C. The size, type and configuration must be applicable to the system operating conditions, including pressures.

D. The operator (control) must be of the bellows type with either a liquid or vapor fill. The valve must be nickel-plated and must contain an EPDM disc and O ring gland seal.

E. The seal must be replaceable without special tools while the system is in operation.

F. The operators shall be with built-in sensors.

2.7 FLOW MEASURING FOR WATER SYSTEMS

A. Furnish and install flow measuring system.

B. Venturi System:

1. Furnish and install one complete Venturi Metering System as manufactured by Barco-Rinco Division of Aeroquip Corporation, Barrington, Illinois, Preso Industries Corporation. This shall be a coordinated system, including individual Venturi Flow Stations and Portable Master Meter, supplied by one manufacturer. Each Venturi station shall be complete with safety shut off valves, fill line size bypass with shut-off valve metal identification tag on chain, giving pipe size, Venturi series station identification, and meter reading at specified flow rate. Entire station shall have same pressure ratings as specified for valves. Venturi size and series shall be selected so that the design flow rate shall be between 10 and 40 inches of water pressure differential on a 0 - 50 meter or 12" - 80" on a 0 - 100" meter, with permanent pressure loss of not more than 10% of indicated flow rate differential pressure. Upstream pipe diameters shall be five (5), and downstream pipe diameters shall be two (2) as recommended by manufacturer.

2. Master Meter shall consist of dry type meter supplied with scale reading from zero (0) to 50 inches or zero (0) to I00 inches of water differential pressure, and shall be mounted in a portable carrying case, complete with two (2) 10 ft. lengths of checking hoses, blow down valves, installation and operating instructions, and capacity curves.

C. Turbine Meter:

1. The meter shall be an insertion turbine flow meter. The turbine meter shall have a linearity of ±1.0% and repeatability of 0.25% with a rangeability of 10:1. (There shall be an indicating meter on the local control panel that will indicate rate of flow and total flow and provide an input signal to the microprocessor controllers.)

2. Provide flow measuring stations for each of the following systems:

(a) AHU-1 thru 5

2.8 STEAM SPECIALTIES

A. Provide steam traps, Armstrong, Spirax-Sarco or approved equal, for venting and draining of steam condensate. Locate at ends of mains, bottom of risers, outlet of steam equipment, and all other points where condensate and air may collect, every

200 feet or less Traps shall pass condensate and air automatically without passing steam. Test in factory to insure operation. Provide strainer at inlet to each trap.

B. Size trap capacities for 200% of steam loads at a maximum drop of ½ psi. Trap capacity should be rated in general accordance with ANCI PTC 39.1 or FCI 87-1. Traps shall be sized with condensate at steam temperature.

C. Thermostatic traps shall be of the corrugated bellows balanced pressure type, bellows of red brass or phosphor bronze.

D. Traps up to and including 2-1/2" shall have flanged or threaded connections. Traps 1" and less shall have union connections.

E. Each steam 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.

F. For each system with 100% outside air provide a thermal drain on each float and thermostatic trap set to open when condensate in trap drops below 75°F. Drain shall be Spirax-Sarco "Thermoton" or approved.

G. Low Pressure Thermostatic Traps (0 PSI - 15 PSI)

1. Low pressure (0-15 psi) Thermostatic traps are to have cast 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 suitable, non-corrosive material. Seats shall be removable, similar to Spirax-Sarco Type T or approved equal.

H. Low Pressure Combination Float & Thermostatic Traps (0 PSI - 15 PSI)

1. 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 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.

2. The traps shall be provided with an automatic, thermostatic air by-pass of the balanced pressure, multiple bellows types, or diaphragm capsule.

3. All working parts shall be of non-corrosive metal, (hard bronze, monel or stainless steel) and shall be removable without disconnecting the piping. Floats to be of stainless steel. Valve heads and seats are to be of stainless steel.

4. Body and cover to be of high grade cast iron suitable for 125 psi pressure for a 0-15 psi line, similar to Spirax-Sarco FT-15, or Armstrong Series "B."

I. Inverted Bucket Traps for Medium & High Pressure Steam 16 PSI to 250 PSI:

1. Provide inverted bucket steam traps with stainless steel internals and ability to have bent hole in bucket be self cleaning. Trap to shut tight on no load and work well over long period of time.

2. Trap must shut tight on no load and must discharge charge air and/or condensate as soon as condensate reaches the trap.

3. Thermo-Dynamic traps or other equivalent type shall not be used on equipment employing modulating control valves.

J. Thermodynamic Disc Traps:

1. Thermodynamic disc type, stainless steel body, disc and cap with only one moving part. Integral seat design with three equally spaced balanced outlet ports, non-gasketed sealing caps and Rockwell 50C hardened disc and integral seat working surfaces. Trap to operate close to saturated steam temperature without steam loss at all pressures from 3.5 psig to 1740 psig and against back pressures up to 80% of inlet pressure. Spriax-Sarco Model TD/TDS.

K. <u>Schedule of Steam Trap Types</u>

Drips for 0 to 30 psig mains and risers:	FT
Drips for mains and risers over 30 psig:	TD
Radiators, convectors, fin-tube radiators:	T
Air heating, blast coils, preheaters and reheaters:	FT
Hot water heaters:	FT
Tank heaters:	FT
Unit heaters:	FT
Flash tank discharge:	F
Heat exchangers:	FT
Absorption refrigeration machine:	FTB

Code:

FT	-	Float and Thermostatic Trap
TD	-	Thermo-Dynamic Trap
T	-	Thermostatic Trap
FTB	-	Float and Thermostatic Trap (high capacity)
IB	-	Inverted Bucket
F	-	Float Trap

2.9 STEAM HUMIDIFIERS

A. Humidifier shall receive steam at supply pressure and discharge at atmospheric pressure.

B. Separating chamber shall be of a volume and design that will disengage and remove all water droplets and all particulate matter larger than 3 microns when humidifier is operating at maximum capacity. A stainless steel filtering medium shall be included, to remove particulate matter in the chamber.

C. The metering valve shall be steam heated and shall have a plug, capable of modulating flow of steam to provide full control over the entire stroke of the operator. Hysteresis of the valve shall be less than 1/2 psig over 100% of valve travel.

D. The internal drying chamber shall receive steam at essentially atmospheric pressure and be jacketed by steam at supply pressure. Asbestos shall not be used anywhere in the humidifier.

E. The silencing chamber shall be steam jacketed and utilize a stainless steel silencing medium.

F. The distribution manifold or manifolds shall provide uniform distribution over its entire length and be jacketed by steam at supply pressure to assure that vapor discharged is free of water droplets. A full length stainless steel internal silencing screen shall be provided if required for sound control.

G. Humidifier shall be equipped with an interlocked temperature switch to prevent the humidifier from operating before start-up condensate is drained.

H. Humidistats specified under "Automatic Controls" will control electric control valve.

I. Provide steam piping, two gate valves, strainer, check valve, and inverted bucket steam trap for each humidifier.

J. Spill condensate from humidifier to drain pans in unit where applicable.

K. Where more than two manifolds are required, the piping shall be as follows. The manifolds shall be jacketed and trapped separately from the humidifier. The humidifier shall receive steam directly from the steam supply line. The trap for the manifolds shall be an F & T trap. The trap for the humidifier shall be an inverted bucket type.

L. Number of manifold and control valves as required by humidifier manufacturer for various duct or air handling unit heights.

2.10 ELECTRIC EVAPORATIVE HUMIDIFIER

A. Humidifier shall be a VAPORSTREAM, Humidifier UL Listed, electric hot element evaporative humidifier as manufactured by DRI-STEEM Humidifier Company, Eden Prairie, MN, or approved equal. having the following features and devices.

B. Stainless Steel Construction: Vaporizing chamber, gasketed cover and fittings shall be constructed of 304 stainless steel with heli-arc welded seams. Chamber shall be capable of operating under a pressure of at least 18" W.C. without steam or water leaks.

C. Standard/DI Water: The humidifier shallrun on standard water, however, it shall have the capability of being field converted to run on demineralized water without being removed from the installation. This shall be accomplished through the use of a universal prove/float assembly and a software change.

D. Quick Removal Cover: The cover shall be secured by quick removal threaded knobs. The gasket shall be held in place by flanges that are formed as part of the cover and as part of the evaporating chamber. Theses flanges shall interlock in such a way that the sealing gasket is locked between them.

E. Immersion Heater(s): Heater(s) shall be Incoloy alloy sheathed resistance type heater(s) designed for no more than 95 watts per square inch. They shall be fastened through the top of the evaporating chamber thus providing for convenient removal for inspection.. The two threaded ends of each heater element shall pass through the top of the evaporating chamber and be secured with threaded nuts to buss bars. Design of heater shall provide for expansion and contraction, thus flaking off scale as it accumulates.

F. Thermal Overload Protection: A manual reset temperature switch shall be factory mounted and wired above a heating element offset to a level above the other heating elements in the evaporating chamber ensuring heater protection in the event of liquid level failure.

G. Heating Element Terminal Cover: A factory mounted and wired door interlock safety switch shall de-energize the heaters when the cover is removed. This provides easy access to quick change heating elements.

H. Inspection Plate/Sediment Tray: Provide tray to catch and hold minerals to facilitate periodic clean-out. This tray rests on the floor of the evaporating chamber. The scale that is shed by the heaters is caught in the tray and the tray is easily removed through the inspection opening for emptying.

I. Electronic Water Level Control for Hard or Softened Water: System shall provide for automatic refill, low water cut off and adjustable skimmer bleed-off functions. System shall consist of:

1. A water level sensing unit comprised of three metallic probes screwed into a threaded probe head. Probe head shall incorporate probe isolation skirts to eliminate short circuiting between probes caused by mineral coating of probe head. Probe head shall be mounted on the top of the vaporizing chamber.

2. A solenoid operated fill valve, brass body type, factory mounted on the front of the humidifier. A cleanable strainer with fine mesh screen shall be mounted upstream of valve. Fill opening shall be 1-1/2" above overflow.

3. Microprocessor Control System.

J. Surface Skimmer/Overflow: Shall be provided which is electronically adjustable to provide for optimum mineral removal with minimum water waste.

K. Control Cabinet: Shall be UL/CSA Listed JIC enclosure. Control devices shall be mounted on a removable sub-panel within the enclosure. Control devices shall include Microprocessor Control System, SCR Controller for each heater, control circuit transformer, fuse set for each heating stage, numbered terminal strip and such other optional devices as hereinafter specified and all interconnecting wiring. A wiring diagram is to be included and attached inside of cabinet door.

L. Microprocessor Control System: Shall be factory mounted and wired in the humidifier control panel with humidity sensors to be shipped loose for field installation by this contractor. Provide necessary contacts for remote monitoring/control by BMS. Mounting instructions and a wiring diagram shall be included and provide the following features and functions:

1. LED “heartbeat” fault indicator. Performs software self-diagnosis at every start-up.

2. Water make-up valve control and low water safety shutdown.

3. Auto drain-flush sequence whereby microprocessor accumulates actual humidifying “ON” time, and activates auto drain/flush sequence.

4. End of season drain function which activates when there has been no demand for humidification over a 72 hour period.

5. Four position functional slide switch on microprocessor board with stops at, “AUTO”, “STANDBY”, “DRAIN”, AND “TEST”.

Electrical contactors shall be cycled equally for long life.

Microprocessor Control System Keypad/Digital Display Module: Shall be housed in a thermoplastic enclosure (4-1/2"w x 6"h x 1-1/2"d). Module shall be shipped loose for field mounting (wiring by this contractor) and shall provide the following features:

M. The alphanumeric digital display portion shall continuously scroll all system functions including:

1. Actual space R.H. (via remote sensor located within the tenant space served by the system, furnished by this contractor)

2. Humidistat set point R.H. (Humidistat furnished by this contractor

3. Discharge duct R.H. (Humidistat furnished by this contractor)

4. High limit humidistat set point R.H. (Humidistat furnished by this contractor)

5. Per heater demand % (or humidifier % multiple humidifier system). Total system demand (in % of total humidifier capacity) total system output (lbs/hr or kg/hr).

6. “Time until service” message

7. High limit Stat and air flow proving circuit condition.

8. Aquastat for freeze protection. (Aquastat furnished by this contractor

N. The keypad portion shall enable the user to reset or adjust the following functions:

1. Humidistat R.H. setpoint

2. Humidistat R.H. high limit setpoint

3. Auto drain/flush frequency interval

4. Auto drain duration

5. Auto flush duration

6. PID loop

7. Throttling range adjustment

8. Time to go until next auto drain/flush sequence

9. Setting of cycle and delay times for proportional control device

10. Electronic skim timer

11. Humidity and temperature transmitter trim adjustments

Factory Mounted Control Cabinet: Cabinet shall be factory attached to side of humidifier and all wiring between cabinet and humidifier shall be completed at factory.

Dual Keypad/Digital Display Modules: Provide two keypad/digital display units, one for local display in the immediate vicinity of the humidifier and the other at a remote location. In addition provide for interface with the BMS (all wiring by this contractor).

O. Master/Slave Control Option:

1. System shall consist of a Master and Slave control management system to control multiple humidifier units (up to 4 humidifiers, 16 heater groups). Heater groups shall be energized or de-energized sequentially while one group modulates, thus providing vernire control. System shall automatically rotate modulating duty between all heater group to equalize operational time and sequence drain/ flush cycles to allow only one humidifier to drain at a time.

P. Control Accessory:

1. Air Flow Proving Switch:

   Vane Type: A vane operated “sail switch” shall be provided for field installation.

2. Duct High Limit Humidistat: A high limit humidistat having a range of 15% to 95% shall be shipped loose for field installation. Humidistat shall sense humidity level within the duct and protect against saturation of air stream.

3. VAV Control Package: Two modulating electronic humidity sensors (one space mounted, the other duct mounted downstream of the humidifier) shall be shipped loose for field installation. Each shall transmit its sensing to the Microprocessor Control System which, in turn, shall modulate the humidifier output thereby maintaining the highest duct humidity possible at all air flow volumes, without saturation of the air stream.

Q. SCR Controllers: Provide SCR controllers for all humidifiers. Provide in control panel, a 100% solid state, power controller. Matching low voltage humidistats shall be shipped loose for field installation (by this contractor). Entire system shall modulate from zero to 100% of rated load.

R. Factory Insulation: Humidifier shall be covered with 1" thick, rigid, foam duct insulation. Insulation shall be covered with reinforced aluminum foil. All surfaces under the removable heater access panel shall be covered.

S. Support Legs: Four support legs, of length to provide 24" between underside of humidifier and floor, shall be provided.

T. Dispersion Tube System: Furnish and install a Dispersion Tube System in each of the air handling units. Each tube bank shall consist of a header/separator and required quantity of dispersion tubes necessary to achieve the required steam capacity and absorption distance. Header/separator shall span the width of the duct, be constructed of stainless steel and be fitted with nipples for dispersion tube connections. Steam dispersion U-tubes shall be 1-1/2" OD, .049" wall, type 304 stainless steel. The dispersion tubes shall extend the width of the duct/air handling unit and shall be fitted with two rows of tubelets centered on the diametric line and spaced 1-1/2" apart. These tubelets shall be made of non-metallic material designed for steam temperatures. Each tubelet shall extend through the wall of and into the center of the dispersion tube and incorporate a properly sized calibrated orifice. For securing the Upper ends of the tubes a 1x1½" channel shall be furnished which the installer shall attach to the duct or housing.

U. Heater Thermostat: A manual reset overheat temperature thermostat mounted in humidifier for redundant protection to main controller.

V. NEMA 12 Rated Fan Ventilation: To provide fan ventilation for humidifier controls installed in the control cabinet. Control enclosure is provided with electric operated exhaust fan, inlet filter grill and step down transformer all mounted and wired (by this contractor).

W. Cold Snap Offset Option: Provide and install on an appropriate window surface a temperature sensor. Sensor shall transmit its signal to the VAPOR-LOGIC which shall lower the indoor RH to a level 5% below the dew point RH thus preventing window condensation. The indoor RH shall be automatically returned to the normal setting when the glass temperature rises.

X. Provide a tempering device similar to Drane Kooler. The device shall temper the hot water or condense steam being drained from the humidifier. The device shall include a mixing chamber and fittings constructed of 304 stainless steel with welded seams. It shall include a self contained brass body tempering valve which shall be temperature adjustable and charged bulb type. The unit shall also include a 3/4" brass bold type drain valve and vacuum breaker. Connect to cold water supply.

2.11 CONVERTORS & EXCHANGERS

A. Furnish and install on suitable pipe frame on structural steel supports, converters and exchangers of size and capacity as scheduled on the drawings. Manufacturer shall be as noted on drawings or approved equal.

B. Convertors:

1. Steam to water convertors shall be water tube hot water heaters of the U-type with steam in the shell and water in the tube. Heater shell shall be constructed of carbon steel plate of ample thickness for the specified pressure with one bumped head, and flange at the other end of the shell. Tube sheet shall be of heavy steel or cast iron, accurately drilled for all tubes. All heating surfaces shall be composed of 3/4" diameter #18 B.W.G. seamless drawn copper U-tubes securely expanded into the tube sheet at one end and properly supported at the other end. All parts of the heater shall be designed for a working pressure of at least 125 p.s.i. in the steam spaces and suitable for the system working pressure in all water spaces. Heater shall have all necessary outlets, drain and vent connections.

2. Furnish and install for each convertor the following appurtenances:

   (a) Steam trap of ample capacity in the return connection (of Webster, or approved, heavy duty trap) with approved Relief valve or valves (Watts Regulator or approved) for connection with the water outlet pipe (between the heater and the shut-off valve). Relief valves shall be furnished by exchanger manufacturer and shall comply with ASME Code. Valves shall be sized to relieve the full output of the convertor in BTU per hour. A vacuum breaker valve shall be mounted on the shell of the heat exchanger.

3. Water to Water Exchangers (Chilled Water to Chilled Water) shall conform to the following: Primary water through tubes, secondary water in baffled shell. Channel type construction with removable cover plate for inspection of tubes with breaking pipe connections. Straight tube construction with fixed tube sheet at each end of shell. Removable return head at far end. Shell and channel shall be fabricated steel ASTM A-285 Gr. C. Tubes shall be Seamless Copper 3/4" OD x l8 Ga. Shell flanges and cover plate shall be steel ASTM A-201 Gr.B. Baffles to be steel. Provide relief valve or valves on secondary water side between exchanger and shut-off valves set l5 p.s.i. above the normal working water pressures at the exchanger. Relief valves shall be furnished by exchanger manufacturer in conformance with applicable codes.

C. This Contractor shall furnish and install all auxiliary steel required for support of all convertors and exchangers.

D. All heat exchangers shall be selected for .0005 fouling factor.

E. Convertors shall be A.S.M.E. constructed and furnished with insurance certificates.

2.12 EXPANSION & COMPRESSION TANKS

A. One or more tanks as required shall be provided for each water system and shall be of the sizes noted on the drawings. Expansion tanks shall be constructed of steel, welded, in accordance with the ASME Code for Unfired Pressure Vessels for a working pressure of 125 psig or 150 percent of maximum operating pressure, whichever is greater. Tanks shall be installed horizontally or vertically as shown on drawings.

B. Each expansion tank shall be piped and fitted in accordance with standard details.

C. Tanks shall be provided with cast iron or steel saddles and structural steel supports from floor except that tanks may be supported from the ceiling structure when load points are detailed on structural drawings. Horizontal tanks of not over 250-gallon capacity may be supported from the ceiling by means of solid steel straps, secured as required for pipe hangers. 80-gallon capacity or smaller tanks may also be supported on cast iron or steel brackets properly secured to walls or columns.

D. Compression tanks shall have one or more ASME rated pressure relief valves set 10% above system working pressure.

2.13 CONDENSATE RECEIVING TANKS & FLASH TANKS

A. One or more tanks as required shall be provided of the sizes noted on the drawings. Talks shall be constructed of steel, welded, in accordance with the ASME Code for Unfired Pressure Vessels for a working pressure of 125 psig or 150 percent of maximum operating pressure, whichever is greater. Tanks shall be installed horizontally or vertically as shown on drawings.

B. Each tank shall be piped and fitted in accordance with standard details.

C. Tanks shall be provided with cast iron or steel saddles and structural steel supports from floor except that tanks may be supported from the ceiling structure when load points are detailed on structural drawings. Horizontal tanks of not over 250-gallon capacity may be supported from the ceiling by means of solid steel straps, secured as required for pipe hangers. 80-gallon capacity or smaller tanks may also be supported on cast iron or steel brackets properly secured to walls or columns.

D. Each tank not vented to the atmosphere shall have one or more ASME rated pressure relief valves set 10% above system working pressure.

E. Internal piping if required by details shall be stainless steel.

2.14 PROPELLER TYPE UNIT HEATERS & ENTRANCE HEATING UNITS (HOT WATER)

A. Furnish and install all unit heaters as shown on the drawings.

B. Unit heaters shall be of the propeller type, suspended as indicated and arranged for horizontal discharge of air. Unit heaters shall be of sizes and capacities as scheduled on the drawings. Heaters shall be of manufacture as noted on drawings or approved.

C. Heating elements shall be copper tube coil with aluminum fins mechanically bonded to copper tubes, shall be properly pitched for drainage, and shall be designed for a working pressure of 200 psi or greater as per system pressures required for valves and fittings.

D. The casing shall be solidly and rigidly built, and finished with lacquer or enamel.

E. Propeller type fans shall be driven by motors of adequate horsepower. Motors shall be provided with thermal overload protection.

F. Furnish and connect to the return of each steam unit heater a float and thermostatic trap of ample capacity, a hand valve, and unions for trap removal.

G. The heaters shall be controlled automatically by means of thermostats located where shown on the drawings which shall start and stop the fans as described under "Automatic Temperature Controls".

H. Furnish and install entrance heating units as shown on the drawings with controls as described under "Automatic Controls".

2.15 PROPELLER TYPE UNIT HEATERS & ENTRANCE HEATING UNITS (ELECTRIC)

A. Furnish and install all unit heaters as shown on the drawings.

B. Unit heaters shall be of the propeller type, suspended as indicated and arranged for horizontal discharge of air. Unit heaters shall be of sizes and capacities as scheduled on the drawings. Heaters shall be of manufacture as noted on drawings or approved.

C. The casing shall be solidly and rigidly built, and finished with lacquer or enamel.

D. Propeller type fans shall be driven by motors of adequate horsepower. Motors shall be provided with thermal overload protection.

E. The heaters shall be controlled automatically by means of local thermostats which shall start and stop the fans as described under "Automatic Temperature Controls."

F. Entrance heating units to be of a capacity as specified in the schedule. Provide fan section and casing construction as outlined in other sections of the specification. Provide 30% medium efficiency filters.

G. Lobby heating units shall be provided with electric heating coil sections with capacities as scheduled on the plans.

1. Electric heaters and controls shall be constructed in accordance with U.L. and NEC requirements.

2. Electric heater frame shall be constructed of heavy duty galvanized steel. All wire terminals and nuts shall be stainless steel. Element wires shall be of A-grade resistance (80% nickel, 20% chromium) and shall be derated to a limit of 35 watts per square inch.

H. Each heater shall be supplied with a built-in automatic reset thermal cut for primary safety protection, replaceable cutouts for secondary safety protection, airflow switch, fan interlock relay, magnetic type contractors (one per step), fuses per NEC, transformer and step controller.

1. Manufacturer to provide a discharge sensor to control leaving air temperature. Provide 3 steps of control as a minimum.

2. All controls shall be housed in a unit mounted control panel with hinged doors, capable of interlock with remote space thermostat.

3. All wiring, control and power, shall be factory installed to terminals such that field wiring is limited to power connections and extension of control terminals to the room thermostat and sail switch.

2.16 CABINET CONVECTORS

A. The convector elements shall consist of seamless copper tubes, non-ferrous fins and mild steel headers. No soldered or welded joints or compression couplings permitted. The convectors shall be designed for a working pressure as per system requirements for valves and fittings.

B. Convector elements shall be supported by the enclosure with approved brackets.

C. Convector shall be suited to the space conditions and shall be of manufacturer as indicated on the drawings or approved.

D. Furnish and install convector enclosures for all convectors. Enclosure shall be constructed as follows: Top, back, sides and bottom of cabinets shall be not less than No. 18 USS gauge steel, fronts shall be not less than No. 14 USS gauge steel, enclosure shall have inlet and outlet grilles.

E. All fully recessed and semi-recessed convectors shall be provided with 16 gauge frame or Perma-lap (top, bottom and sides). All convectors shall be prime coat finish.

F. All enclosures shall be braced to provide stiffness. Convectors shall be securely bolted to the wall. Provide 1/2 inch of rigid insulation on sides, top, bottom and back of all convectors installed in outside walls.

G. All convectors without thermostatic control shall be provided with a knob operated gear type damper.

H. Where indicated on drawings heating elements shall be installed in enclosures provided under another division of the work. This trade shall furnish and install the sheet metal lining and insulation, inlet grilles and outlet registers.

2.17 CABINET UNIT HEATERS

A. Furnish and install of manufacturer as shown on the plans, or approved, cabinet heaters of size and type indicated. Design system pressures as per valves and fittings.

B. <u>Unit Casings</u> - Casings shall be constructed of die-formed, heavy gauge steel parts, phosphatized for rust resistance, front and all exposed surfaces shall be brushed aluminum finish. All hardware used in the casing shall be plated for rust resistance. Cabinets shall be constructed with well-rounded corners, and shall be equipped with a removable front for access to the interior.

C. <u>Heating Elements</u>

Heating elements shall be constructed of copper tubes and aluminum plate-type fins. Tubes are to be 1/2" O.D., and shall be joined to the supply and return header by silver brazing. Headers are to be fabricated from heavy gauge steel with provision for receiving an air vent. The aluminum fins shall be spaced by means of an integral collar to insure proper spacing. The joint between fin and tube shall be obtained by mechanically expanding the tube within the collar to affect a permanently tight thermal contact. The heating elements shall be of the multi-pass serpentine type, with the supply and return connections both located at the same end of the unit.

1. Heating elements shall be held rigidly in the unit casing, yet provisions shall be made to allow freedom for expansion and contraction within the casing.

D. Fans - Fans shall be forward-curved, double-inlet aluminum, mounted on a large-diameter steel shaft. The shaft shall be carried by two permanently lubricated, rubber-mounted ball bearings at shaft ends. Fans, shaft, bearings and fan housings shall be mounted as an integral assembly on a heavy steel fan board which is bolted to the unit. Fan drive shall be the V-belt type employing a fixed-pitch fan shaft sheave and an adjustable pitch motor sheave. Motor sheave adjustment shall permit a 30% adjustment of fan speed. All motors shall be provided with built-in thermal overload protection of the automatic reset type, with on-off-automatic control switch.

E. Filters - All cabinet unit heaters shall be provided with dry type filters. Furnish 2 spare filters for each unit.

2.18 FINNED PIPE RADIATION AND ENCLOSURES (SILLINE)

A. Furnish and install where shown on the plans, silline radiation complete with one piece back panel, one-piece front enclosures, heating element, hangers and accessories . Silline radiation shall be of manufacturer as indicated on the drawings or approved. Design system pressures as per valves and fittings.

B. Enclosure front shall consist of a one-piece No. I6 gage steel cabinet, with curved, streamline louvre discharge grille and die-formed bottom air-inlet openings. Each enclosure front shall be rigidly braced by integral vertical channel braces. Each front shall extend to the wall and be fastened to the back panel at both top and bottom. Each front enclosure shall have two spring-loaded thumb screw fasteners, spot-welded in position for quick installation or shall be snap-on type. Back panel shall be of one-piece, 20 gage steel. Back panel shall be prepunched for fastening to wall and attaching heating element hangers.

C. Support brackets for the heating elements shall attach to the back panel. They shall be vertically adjustable for pitch, and shall provide for free longitudinal movement for expansion and contraction. Hanger bars shall be installed with nylon trim to prevent noise during expansion and contraction of heating element.

D. No sheet metal screws or other fastenings devices shall be visible when enclosure is installed below eye level. Where two or more enclosure sections are joined end to end, rolled enclosure edges shall form a neat butt joint without butt straps or other concealing devices. No unfinished metal edges of the ensemble shall be visible.

E. Heating elements shall be constructed of corrugated 015" aluminum fins mechanically expanded to seamless type "M" copper tubing. One end of each heating element shall be provided with swaged ends to permit end-to-end jointing.

F. Enclosures and accessories shall be finished in a hard baked (in a color selected by the architect) enamel finish. Enclosure and accessories shall be cleaned and phosphate coated before finishing.

G. All accessories shall be die-formed of l8-gage steel, and shall be shaped to match the enclosure form. All corners shall be rounded and all surfaces smooth. Accessories shall have no exposed metal edges, and fastening devices shall not be visible in below-eye-level installation. All necessary accessories shall be provided to permit wall-to-wall installation without cutting enclosures.

H. <u>End Caps</u> - Where one or more sill line enclosures are shown on the plans in a short-of-wall installation, the ensemble shall be finished at either end with a smooth rounded end cap. End cap shall provide a bottom or back knockout for piping as required.

I. <u>Corners</u> - Where two enclosures meet at a 90° inside or outside corner, rounded corner pieces shall be used.

J. <u>Sleeves</u> - Where sill-line ensemble runs wall-to-wall or corner-to-corner, fitted sleeves shall be used in conjunction with wall strips or corner pieces. Sleeves shall have rounded edges, and shall be shaped to telescope over enclosure, concealing variations between the overall enclosure length and the actual room length. Sleeves shall be arranged on combination with properly selected enclosure lengths to permit unbroken wall-to-wall installation without cutting enclosures.

K. Wall Strip - Where sill-line installations run wall-towall, wall strips shall be used to finish out the ensemble to the end walls. Wall strips shall provide a neat, tight groundjoint between the sleeve and the end wall.

L. <u>Full Access Valve Compartment</u> - For access to valves, balancing fittings, etc., a one foot piece of sill-line enclosure shall be provided. This one foot piece of enclosure shall match the sill-line ensemble and be complete with two spring loaded, thumb screw fasteners, spot welded in position for easy removal of and replacement of the enclosure.

M. <u>Column Enclosures</u> - Where indicated on the plans, piping around columns shall be concealed in column enclosures provided by the radiation manufacturer. These enclosures shall consist of one-piece back panels, rounded front panels, and trim strips. Hangers for supporting piping shall be included. Column enclosures shall be suitable for cutting and fitting at the job site to conform to column dimensions, and shall be finished to match the enclosure.

N. Dampers - Each enclosure without thermostatic control shall be provided with a knob-operated screw mechanism and shall be modulating control of the convective heating capacity.

2.19 BURIED HOT WATER PIPING

A. All underground and aboveground hot water lines with fluid temperatures up to 250° shall be the POLY-THERM type, as manufactured by PERMA-PIPE.

B. All straight sections, fitting, anchors and other accessories shall be factory fabricated to job dimensions and designed to minimize the number of field welds.

C. Each system layout shall be computer analyzed by the piping system manufacturer to determine stress on the carrier, pipe, and anticipated thermal movement of the service pipe. The system design shall be in strict conformance with ANSI B31.1, latest edition. Factory trained field technical assistance shall be provided for critical periods of installation; unloading, field joint instruction, and testing.

D. Internal piping shall be standard weight carbon steel. All joints shall be butt-welded for 2 ½" and greater, and socket or butt-welded for 2" and below. Where possible, straight sections shall be supplied in 18' or longer random lengths with 8" of piping exposed at each end for field joint fabrication.

E. All system components shall be designed and factory fabricated to prevent the ingress of moisture into the system.

F. Carrier pipe insulation shall be spray applied nominal 2 pound per cubic foot density, polyurethane foam for straight sections and performed polyurethane foam for all fittings. To ensure no voids are present, all insulation shall be inspected by one of the following three methods: visually checked prior to application of the protective jacket; infrared inspection of the entire length; or x-ray inspection of the entire length. The insulation thickness shall not be less than as specified under another section.

G. All straight sections of the insulated piping system shall be fully jacketed in a filament wound, polyester resin/fiberglass reinforcement composite directly applied on the insulating foam. Thermoplastic casing material, e.g., PVC or PE, shall not be allowed.

H. The minimum thickness for FRP jacket shall be as follows: For jacket diameter up to 15.5 inches-thickness = 0.055 inches; jacket diameter between 15.6 and 24.5 inches-thickness = .085 inches; jacket diameter between 24.6 and 31.0 inches-thickness = .110 inches; and jacket diameter between 31.1 and 40.0 inches-thickness = .140 inches.

I. All fittings of the insulated piping system shall be prefabricated to minimize field joints and jacketed in a chopped spray-up, polyester resin/fiberglass reinforcement composite, directly applied onto the insulating foam to a thickness related to the filament wound jacket thickness.

J. Field Joints:

1. The internal pipe shall be hydrostatically tested to 150 PSIG or 1½ times the operating pressure, whichever is greater. Insulation shall then be poured in place into the field weld area. All field applied insulation shall be placed only in straight sections. Field insulation of fittings shall not be acceptable. The mold for the polyurethane shall be made of clear adhesive backed polyester film. The installer shall seal the field joint area with wrappings of glass reinforcement fully saturated with a catylzed resin identical in properties to the factory-applied resin. Backfilling shall not begin until after the jacket has cured. All insulation and coating materials for making the field joint shall be furnished by PERMA-PIPE.

K. Backfill:

1. A 6" layer of sand or fine gravel shall be placed and tamped in the trench to provide a uniform bedding for the pipe. The entire trench width shall be evenly backfilled with a similar material as the bedding in 6 inch compacted layers to a minimum height of 12 inches above the top of the insulated piping system. The remaining trench shall be evenly and continuously backfilled in uniform layers with suitable excavated soil.

2.20 SNOW MELTING SYSTEM

A. The system shall consist of pumps, convertors, piping, controls, anti-freeze, etc.

B. Provide for each grid section factory lubricated teflon coated plug valve on supply and return lines.

C. Piping shall be securely supported at maximum 6'-0" O.C. with proper alignment and pitch for draining. The system shall be tested for leaks with air or nitrogen at 25 psig minimum.

D. The heating medium shall be 42.7% ethylene glycol.

E. Wherever possible single length of piping shall be used for all grids. Welding will be permitted only if single length piping is not available. Couplings will not be permitted. Grid piping shall be welded into headers in a manner to insure freedom from weld drips maintaining clean full area bores.

F. Entire piping system shall be electrically checked for freedom from stray current. (No electrical grounding to the system will be permitted).

G. Provide cathodic protection in the form of two magnesium anodes with test leads to a convenient terminus.

2.21 UNDERGROUND STEEL CONDUIT

A. Conduit:

1. All conduit straight lengths shall be welded smoothwall of not less than 10 gauge wall thickness black steel for all sizes and shall be tested at the factory to insure air and watertight welds prior to any fabrication or application of resin coatings. Conduit surfaces, inside and outside, shall be cleaned and made free of all loose scale and mill coatings by sand blasting to clean bright metal, and care shall be taken to maintain the surfaces free of oil and grease, before application of coatings. After sandblasting, the conduit surfaces, inside and outside, shall be given a prime coat of epoxy resin modified for the purpose intended and in preparation for the finish coats. Finish coat of epoxy resin on interior surface shall be applied in one pass to effect a final minimum coating thickness of not less than 6 mils. Exterior finish coat shall be applied to a minimum thickness of 20 mils by the additional application of two alternately applied layers of glass cloth and in such a manner as to fully impregnate each layer with resin as the layers are applied.

2. All primer coats and finish coats shall be of the catalytic epoxy type, unmodified except for necessary dispersants and flow control agents, total modification not to exceed five percent of the vehicle solids. No modification or substitution of additional coatings of other types is permissible. The iron-oxide-zinc chromate catalyzed primer shall contain not less than 60 per cent

solids after mixing the two components but before reduction. Of these solids the iron oxide pigment shall be 1.50 - 2.00 pounds per gallon and shall contain not less than 75 percent ferric oxide. The zinc chromate shall be .50 pounds per gallon minimum and the magnesium silicate 1.5 to 2.0 pounds per gallon. The vehicle portion of the primer shall consist of 65 percent epoxy resins (Shell 1001) and 35 per cent resinous curing agent with no more than 5 per cent of the vehicle as stabilizer and flow control agents.

3. The finish coat shall contain not less than 60 percent solids after mixing the two components but before reduction. The pigment shall consist of 2 pounds per gallon of chromium oxide with the addition of not more than 3 percent of the pigment as dispersants and suspending agents. The finish coat vehicle shall consist of (Shell 1001) epoxy resin and a resinous Nitrogen containing curing agent in the ratio of 65 per cent epoxy resin to 35 per cent curing agent with the addition of not more than 5 per cent of stabilizers and flow control agents.

4. Final outside coating shall be subjected to a spark test and be capable of maintaining dielectric strength of 10,000 volts.

5. Conduit closures of suitable length complete with pipe insulation shall be furnished by the system manufacturer and shall be cylindrical in form of I0 gauge steel with a single horizontal side split. Closures shall be supplied with necessary prime coating and one finish coat, inside and outside, of epoxy resin same as conduit.

6. Installation of closures shall occur in the field by the Contractor at points of field joints between straight units or fabricated fittings, and shall be welded centrally over conduit ends between such adjacent units.

7. After welding a pressure testing using 15 lbs. air shall be made, and all welds shall be examined and checked for leaks by applying a soapy solution to the weld area. Any leaks shall be rewelded and the system retested until airtight at 15 lbs. pressure.

8. The Contractor shall furnish all necessary equipment and labor to perform the air test, including air compressor, gauges, conduit caps, temporary pipe and connections, etc., and complete the test to the satisfaction of the architect and/or engineer.

9. Upon completion of test and as soon thereafter as possible, all field welds on closures shall be cleaned of all welding slag, burned coating, mud, etc., by wire brushing.

10. Coupler shall then be finish coated in accordance with the system manufacturer's instructions, using materials supplied.

11. Finished coating shall then be spark tested as hereinbefore specified for straight units.

12. Additional conduit accessories as hereinafter specified shall have all exposed surfaces coated with resin same as conduit.

13. The whole system, prior to backfill, shall be subjected to a final spark test, and any electrical leaks caused by scuffing or other physical damage to coating shall be made good.

B. Pipe and Pipe Supports

1. All piping in conduit shall be as specified for the service required. All field pipe joints shall be welded by competent mechanics and hammer tested under hydrostatic pressure of 250 psi or twice the working pressure, whichever is greater, unless otherwise specified. Concealed pipe welds in fabricated conduit fittings shall be factory tested the same as specified for field welds, prior to assembly.

2. Piping shall be suitably spaced in the conduit and shall be supported in such a manner to avoid stress on wear on the pipe and/or insulation. Pipe supports shall consist of full, round insulating discs with specially corrugated steel band outer periphery to allow free air passage within the casing from one side to the other and to afford minimum line contact with inner surface of conduit. Supports shall be spaced on not more than 10'-0" centers with metal surfaces of supports protected with epoxy resin coating same as for conduit.

C. Expansion Loops, Ells and Tees

1. Prefabricated ells, loops and tees shall be furnished and installed where shown on plans and shall consist of pipe, insulation, and conduit conforming to the same specification as hereinbefore specified for straight runs. Expansion loops shall be of proper design in accordance with stress limits indicated by A.S.M.E. Code for pressure piping, District Heating Section. Loop piping shall be installed in conduit suitably sized to handle indicated pipe movement.

D. End and Gland Seals

1. Terminal ends of conduits inside manholes, pits or building walls shall be equipped with end seals consisting of a steel bulk head plate welded to the pipe and conduit. Where there is no anchor within five feet of a terminal end, conduits shall be equipped with gland seals consisting of a packed stuffing box and gland follower mounted on a steel plate welded to end of conduit. End seals or gland seals shall be equipped with drain and vent openings located diametrically opposite on the vertical center line of the mounting plate and shall be shipped to the job site with plugs in place.

E. Waterstops or Leakplates

1. All conduits shall terminate 1" beyond inside face of manhole or building walls to prevent condensation drip from spilling over exposed piping insulation in pits. Conduit shall be equipped with leak plates or water stops located in wall approximately 5" from terminal ends to provide effective moisture barrier.

F. Anchors

1. Prefabricated plate anchors shall be furnished and installed where shown on plans and shall consist of a steel plate, welded to pipe and conduit. The steel plate shall be 3/8" thick for 6" to 10" conduit, 1/2" thick for 11-1/8" to 20" conduit and 3/4" thick for conduit over 20".

2. A concrete block shall be cast over the plate and conduit and shall be large enough for firm anchorage into undisturbed trench sidewalls. The concrete block to be at least 30" in length and extend a minimum of 9" beyond the top and bottom of anchor plate.

G. Pipe Insulation

1. All pipe or pipes in conduit, as hereinafter specified, shall be insulated with machine-molded 1-1/2" fiberglass cloth jacket. Side joints of insulation jackets shall be double stitch sewn with fiberglass thread and with end joints telescoped not less than 2 inches when applied. For chilled water piping, refer to insulation section.

2. The factory prefabricated insulated pipe conduit specified above shall be Imperial Line as supplied by Ric-Wil Incorporated, Barberton, Ohio, or equal, and installed under the supervision of a factory installation supervisor.

H. Cathodic Protection

1. Cathodic protection shall be provided for the buried systems furnished under these specifications.

2. The cathodic protection system consists of furnishing the design and materials, and performing all operations necessary to provide a flow of direct current from sacrificial anodes to the underground heating and cooling distribution systems.

3. The manufacturer of the heating conduit system shall be responsible for furnishing the design and materials for the cathodic protection of their particular system.

4. The system shall be designed with not less than 7% of the heating conduit surface considered bare and not less than 2 milliamps of current per square foot of bare surface. Seventeen pound magnesium anodes shall be used, sufficient for a 30 year life.

5. Test stations shall be provided along the conduit, not more than 500 feet apart, to test performance after installation. Terminate test leads at ground surface in a cast-iron housing encased in concrete, with approximately 18" of slack lead. Where buildings or structures are close by, test leads shall be housed in electrical conduit and terminated in waterproof junction boxes affixed to the structure.

6. Arrangements shall be made to electrically isolate the heating and cooling distribution piping under cathodic protection from other buried structures.

7. Special attention shall be given to buried electrical connections. These connections must be carefully checked and protected before backfilling. Backfill material around buried wires shall be free of stone and other sharp objects.

8. Before commencement of the installation, an earth resistivity survey shall be undertaken along the line of conduit, employing specialists in that field. At this time, samples of soil at anticipated pipe depth shall be obtained and the chemical analysis and electrical resistivity for each sample determined. Chemical analysts shall include pH, percentage of water soluble salts, chloride content and sulphate content A minimum number of five samples shall be taken from representative locations along the route.

9. Before final acceptance of the cathodic protection system, a detailed, dimensional drawing shall be furnished showing exact locations of all anodes, test stations and the routes of all connecting cables. Methods of installing the materials shall also be detailed on this drawing.

10. The system shall be tested after installation has been completed and a report submitted. Additional anodes or alterations shall be provided as required for satisfactory operation of the system.

11. Proper installation of the cathodic protection system in accordance with the drawings shall be the responsibility of the contractor. However, a technically qualified representative from the designers of the cathodic protection system shall be present during the installation of the anodes and the test stations. The representative shall report in writing to the consulting engineers any work not in conformance with his recommendations. On completion of the work, the company responsible for the design of the cathodic protection system shall submit a certified letter stating that the installation has been made in accordance with the specifications and their recommendations.

12. The system under this section of the specifications shall be guaranteed for a period of one year from date of acceptance thereof. Upon receipt of notice of failure of any part of the system, during the guaranty period, the affected part or parts shall be replaced promptly with new parts by and at the expense of the contractor.

2.22 THERMOMETERS AND PRESSURE GAUGES

A. Furnish and install pipe thermometers with separable sockets in the following locations. This applies to all systems described in the specification. Thermometers to be rated at minimum range 150% and maximum 200% of working temperature.

1. In and out of each cooling tower.

2. In and out of each refrigerant condenser and chiller. Thermometers as required under "Refrigeration Equipment".

3. In and out of each converter and water to water exchangers (on water side).

4. In return secondary water and in mixed water line after bleed valves on all bleed systems.

5. In and out of each chilled water coil. A vertical bank of coil sections may have one thermometer on inlet header and one on outlet header. For these systems with two vertical banks of coils, then each bank shall have a thermometer on inlet and outlet headers.

6. In and out of each heating coil in main air supply rig. A vertical coil bank section may have one thermometer on inlet header and one on outlet header. For those systems with two vertical banks of coils, then each bank shall have a thermometer on inlet and outlet headers.

7. In condensate receiving or dilution tanks.

B. Furnish and install pressure gauges in the following locations on water lines:

1. At inlet and outlet of each circulating pump and upstream of inlet strainer. One gauge may be used in lieu of two on suction side of pump with suitable valves and piping. Pressure gauges to be rated at minimum 150% and maximum 200% of working pressure. If suction head on pump is below 5 PSI, furnish a compound gauge. Pumps to be provided with gauges in tapping provided for by pump vendor in pump nozzles.

2. At inlet and outlet of refrigerant water chiller.

3. At inlet and outlet of refrigerant condenser.

4. At inlet and outlet of each converter and water to water exchanger (on water side).

5. At inlet and outlet of each coil bank. For those systems with two banks of three coils each, each bank shall have separate gauges. Locate gauges immediately downstream of shut-off valve on supply line, and immediately upstream of shut-off valve on return line.

6. On discharge of condensate pumps.

7. As required for compressed air lines described under automatic controls.

C. See "Automatic Controls" for description of air thermometers to be provided by automatic control manufacturer.

D. Thermometers for water systems shall be direct red reading, 9" vertical scale, 1 degree increments, manufactured by Weksler, Moeller, or Taylor and shall be minimum 4-1/2 inch dial type, aluminum flangeless case.

1. Pipe insertion dial thermometers shall have separable sockets of a material suitable for each given installation. Sockets for insulated lines shall have 2-1/2" extension necks.

2. They shall be of the adjustable angle type to permit easy adjustment of the thermometer case, to facilitate reading after installation.

E. Pressure gauges shall have 4-1/2" diameter dials, cast aluminum case, wide phosphor bronze bourdon, stainless steel movement, micrometer adjustment pointer, 1/2 of 1% accuracy, ranges as required. Shut-off cock shall be provided between each gauge and piping to permit removing gauge while system is under pressure. All gauges on steam piping shall be provided with syphons. All gauges on pumps shall be provided with pressure snubbers. Gauges as specified above shall be TRERICE 500X series, WEKSLER AAI series, WEISS PG series, ASCHROFT Duragauge series, or approved equal. Mount gauges so that they are clearly visible from floor level. Provide extension tubing as required.

2.23 PLATE HEAT EXCHANGER

A. The plate heat exchangers shall be shipped to the site as completely assembled units. The exchangers shall be pressure tested and flushed clean at the factory prior to shipment. All nozzle connections shall be factory sealed prior to shipment to prevent the entrance of foreign matter into the heat exchangers during shipment, storage and installation.

B. Applicable Codes and Standards:

1. The plate heat exchangers shall be factory tested in accordance with the requirements of Section VIII, Div. I of the ASME Code.

2. Flanged nozzle connections shall conform to ANSI B16.5 standards, and shall be of the pressure rating design as indicated on the schedule. Pressure ratings assume full pressure on one side and zero pressure on the other side. Studded port construction is not acceptable.

C. Design Requirements:

1. Heat exchanger performance and design shall be in accordance with the schedule. Surface area shown per plate heat exchanger is the minimum acceptable. All performance calculations must include a minimum of ten percent (10%) additional surface for fouling. Calculated heat transfer surface area, with and without the additional fouling surface, must be indicated on the manufacturer's submitted performance calculation data sheets. Heat transfer rates fouled in excess of 750 BTU/HR/FT^2/Deg. F are not acceptable.

2. Pressure drops in pounds per square inch across each circuit of the plate heat exchanger indicated on the schedules are the maximum allowed.

3. Heat exchanger design is to be of diagonal flow to optimize fluid flow distribution across the plate surfaces.

D. Construction Requirements:

1. Plates shall be fabricated from SA312-304 stainless steel having a 2B finish. Pattern shall be Chevron and shall be of a minimum thickness as indicated for the following Design/Test Pressure requirements:

   (a) 150 psi design/225 psi test - .024 inches minimum plate thickness.

2. Gaskets shall be of a one piece molded design formulated of Nitrile rubber. Inactive port gasket areas shall be vented to the exterior in such a manner that no mixing can occur between fluid circuits.

3. Nozzles shall be flanged and shall comply with the requirements of ANSI B 16.5 for a 300 pound - 150 pound rating where applicable.

4. Heat exchanger frames shall have a minimum of two external lifting lugs per frame.

5. Each heat exchanger shall be fitted with a removable galvanized steel plate pack shroud with attached lifting handles; and shall completely enclose the plate pack, front/rear covers, and tie bars.

6. Plates shall be supported from an upper carrying bar and positioned by a lower guide bar. Plates shall not require the use of additional hanging clips for either support or positioning.

7. Frame shall be constructed of carbon steel in sufficient thickness and strength to operate within the designated design and test pressures. Design strength calculations are to be submitted at the Engineer's request.

8. Frame tightening bolts shall receive a rust-protective coating of molybdenum grease and shall also be covered with plastic sleeves.

9. All exposed frame parts shall be surface prepared to an SSP-6 finish, receive two prime coats of a glycerophtalic zinc chromate primer and two finish coats of an epoxy enamel to a minimum dry film thickness of 3mm.

E. Testing and Certification:

1. All factory hydrostatic testing of the plate heat exchangers is to be scheduled in conjunction with the Engineer to determine if the Engineer deems it necessary to have his representative available.

2. The plate heat exchanger manufacturer is required to make factory representation available should field thermal and/or pressure testing be required.

F. Approved Manufacturers:

1. Plate heat exchangers are as manufactured by American Vicarb Corporation.

2. Other manufacturers' plate heat exchanger equipment will be considered for approval providing:

   (a) All design, construction and performance specifications are strictly adhered to; and

   (b) Sufficient reference material can be supplied by the manufacturer exhibiting a minimum of five years similar industry experience.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping before welding.

3.2 INSTALLATION

A. Installation of Appurtenances and Sensors in Piping:

   1. Provide all fittings, wells and openings required for installation of devices to indicate flow, temperature, pressure, etc., in piping systems.

B. Piping Systems - General:

   1. The drawings indicate schematically the size and location of piping. Piping shall be set up and down and offset to meet field conditions and coordination between trades without additional cost. Piping shall conform to the latest revisions of ANSI/ASME B31.9 - "Building Services Piping."

   2. Pipework shall conform fully to the following requirements:

      (a) 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.

      (b) 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 with steel faces can be used on piping 1" or less.

      (c) 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.

      (d) 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 new approved and necessary fittings, air vents, or vacuum breakers at no extra cost. If connections are concealed in furring, floors, or ceilings, this trade shall bear all expenses of tearing up and refinishing construction and finish, leaving same in as good condition as before it was disturbed.

3. Pitch steam and condensate lines downward in direction of flow to ensure adequate flow and prevent noise and water hammer. 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. 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 degree 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 outdoor air heating coils, domestic hot water heaters and steam-water converters, shall have a vacuum breaker installed as shown on details.

4. Pitch water piping upward in direction of flow to ensure adequate flow without air binding, and to prevent noise and water hammer. Branch connections to mains are to be made in such a manner to prevent air trapping and permit free passage of air. To meet job conditions mains shall set up to maintain headroom, and clear other trades. Provide oversized float operated automatic air vent (with valve & strainer) at all high points particularly at the highest points of return mains and risers and high points of supply risers. Avoid 90 degree lift set-ups in supply lines by using 45 degree ells. Where 90 degree lifts exceed 12" install automatic air vent in supply lines. All lifts in return lines shall be installed with automatic air vents. Pipe outlet of all automatic air vents to an open sight drain if the vent is concealed, or to within two feet of the floor within machine rooms.

5. Miscellaneous drains, vents and reliefs are to be provided as follows:

   (a) Provide 1" drain valves with caps at the heel of all interior main water risers. Provide 1/2" drain valves with caps at the heel of all perimeter water risers.

   (b) Miscellaneous drains, vents, reliefs, and overflows from tanks, equipment, piping relief valves, pumps, etc., shall be run to the nearest open sight drain or roof drain. Provide drain valves whenever required for complete drainage of piping, including the system side of all pumps.

(c) Provide domestic water connections from valved outlets to any equipment requiring same.

(d) Provide automatic relief valves set 50# psi below rating pressure of all hot water heating vessels on vessel or in leaving hot water line on vessel side of any valve.

(e) Contractor shall cap or plug in all systems, all open ended valves for future connections, drains and vents. Also, in order to prevent a dead leg of water and consequent corrosion, provide a 1" open bypass from supply to return with balancing valve in all open condenser water systems.

6. Screwed piping shall conform to the following:

(a) Pipe nipples - Any piece of pipe 3" in length and less shall be considered a nipple. All nipples with unthreaded portion 1-1/2" and less shall be extra heavy. Only shoulder nipples shall be used. No close nipples will be provided.

(b) Screw threads shall be cut clean and true; screw joints made tight without caulking. No caulking will be permitted. A non-hardening lubricant will be permitted. No bushings shall be used. Reductions, otherwise causing objectionable water or air pockets, to be made with eccentric reducers or eccentric fittings. All pipe shall be reamed out after cutting to remove all burrs.

END OF SECTION 15500

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes the following categories of HVAC pumps for hydronic systems:

1. Vertical in-line Pumps (150 PSIG Working Pressure).

2. Vertical in-line Pumps (350 PSIG Working Pressure).

3. Closed Coupled, End-Suction Pumps.

4. Frame Mounted, End-Suction Pumps.

5. Horizontal Axial Split-Case, Double Suction Pumps

6. Duplex Condensate Pump units.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Section 15010 BASIC MECHANICAL REQUIREMENTS

2. Section 15050 BASIC MECHANICAL MATERIALS AND METHODS

3. This section is a part of each Division 15 section.

4. Division 16 ELECTRICAL

1.3 SYSTEM PERFORMANCE REQUIREMENTS

A. Pump Pressure Ratings: At least equal to system's maximum operating pressure at point where installed, but not less than specified. Factory test at 1.5 times working pressure.

B. Water Temperature: Pump to comply with specific application.

C. Mounting: As described under "Vibration Isolation".

D. 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.

E. Rising Curve: Pump characteristic curve shall rise continuously from maximum capacity to shut-off, with shut-off head minimum 10 percent greater than the design head, except for double suction pumps to shut-off head shall be 20 percent greater than design head.

F. Working Pressure: Construct pumps for the working pressure in pounds per square inch specified or indicated. Factory test at 1.5 times working pressure.

G. Factory Tests: The pumps shall be factory tested, thoroughly cleaned and painted with (1) coat of machinery enamel prior to shipment. The manufacturer shall include a set of installation instructions with the pumps at the time shipment.

1.4 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data including certified performance curves and rated capacities, brake horsepower, KW input and full load efficiency complying with motor efficiency requirements. In addition, include weights (shipping, installed, and operating), furnished specialties, and accessories. Indicate pump's operating point on curves.

C. Shop drawings showing pump layout and connections. Include setting drawings with templates, directions for installation of foundation and anchor bolts, and other anchorages.

D. Wiring diagrams detailing wiring for power, signal, and control systems and differentiating between manufacturer-installed wiring and field-installed wiring.

E. Product certificates signed by manufacturers of pumps, certifying accuracies under specified operating conditions and compliance with specified requirements.

F. Maintenance data for pumps to include in the operation and maintenance manual specified in Division 1. Include startup instructions.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with provisions of the following:

1. ASME B31.9 "Building Services Piping" for piping materials and installation.

2. Hydraulic Institute's "Standards for Centrifugal, Rotary & Reciprocating Pumps" for pump design, manufacture, testing, and installation.

3. UL 778 "Standard for Motor Operated Water Pumps" for construction requirements. Include UL listing and labeling.

4. NEMA MG 1 "Standard for Motors and Generators" for electric motors. Include NEMA listing and labeling.

5. NFPA 70 "National Electrical Code" for electrical components and installation.

B. Single-Source Responsibility: Obtain each category of pumps from a single- source and by a single manufacturer. Include responsibility and accountability to answer questions and resolve problems regarding compatibility, installation, performance, and acceptance of pumps.

C. Product Options: Drawings indicate sizes, profiles, connections, and dimensional requirements of pumps and are based on the specific types and models indicated. Other manufacturers' pumps with equal performance characteristics may be considered. Refer to Division 1 Section "Product Substitutions."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store pumps in dry location.

B. Retain shipping flange protective covers and protective coatings during storage.

C. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

D. Extended Storage Longer than 5 Days: Dry internal parts with hot air or vacuum-producing device. Coat internal parts with light oil, kerosene, or antifreeze after drying.

E. Comply with pump manufacturer's rigging instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: The following vendors will be reviewed for approval providing they meet all of the performance requirements of the specifications.

1. Vertical In-Line Pumps:

(a) Allis-Chalmers Fluid Products Co.; Industrial Pump Div.

(b) Amtrol, Inc.

(c) Armstrong Pumps, Inc.

(d) Burks Pumps, Inc.; Weinman Pump.

(e) Deming Pump Co.

(f) Dunham Bush, Inc.

(g) Goulds Pumps, Inc.

(h) ITT Fluid Technology Corp.; Bell & Gossett Div.

(i) Paco Pumps, Inc.

(j) Peerless Pump Co.
(k) Taco, Inc.

2. Close-Coupled, End-Suction Pumps:

(a) Allis-Chalmers Fluid Products Co.; Industrial Pump Div.

(b) Burks Pumps, Inc.; Weinman Pump.

(c) Deming Pump Co.

(d) Dunham Bush, Inc.

(e) Goulds Pumps, Inc.

(f) ITT Fluid Technology Corp.; Bell & Gossett Div.

(g) Paco Pumps, Inc.

(h) Peerless Pump Co.

(i) Taco, Inc.

(j) Weil Pump Co.

3. Frame Mounted, End-Suction Pumps:

(a) Allis-Chalmers Fluid Products Co.; Industrial Pump Div.

(b) Burks Pumps, Inc.; Weinman Pump.

(c) Deming Pump Co.

(d) Dunham Bush, Inc.

(e) Goulds Pumps, Inc.

(f) ITT Fluid Technology Corp.; Bell & Gossett Div.

(g) Paco Pumps, Inc.

(h) Peerless Pump Co.

(i) Taco, Inc.

(j) Weil Pump Co.

4. Horizontal Axial, Split-Case, Double-Suction Pumps:

(a) Allis-Chalmers Fluid Products Co.; Industrial Pump Div.

(b) Burks Pumps, Inc.; Weinman Pump.

(c) Deming Pump Co.

(d) Dunham Bush, Inc.

(e) Goulds Pumps, Inc.

(f) ITT Fluid Technology Corp.; Bell & Gossett Div.

(g) Paco Pumps, Inc.

(h) Peerless Pump Co.

(i) Taco, Inc.

(j) Weil Pump Co.

2.2 PUMPS, GENERAL

A. General: Factory assembled and tested.

B. Base-Mounted Pumps: Include pump casings that allow removal and replacement of impellers without disconnecting piping.

C. Types, Sizes, Capacities, and Characteristics: As indicated.

D. Motors: Furnish single-, multiple-, or variable-speed motors, with type of enclosures and electrical characteristics indicated and as specified under another section of this work. Include built-in thermal-overload protection and grease-lubricated ball bearings. Select each motor to be nonoverloading over full range of pump performance curve.

E. Factory Finish: Manufacturer's standard paint applied to factory-assembled and -tested units before shipping.

F. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

2.3 VERTICAL IN-LINE PUMPS (150 PSIG Working Pressure)

A. Description: Vertical, in-line, centrifugal, closed coupled, single-stage, radially split case design. Include vertical-mounting, bronze-fitted design and mechanical seals rated for 150 psig minimum working pressure and a continuous water temperature of 250 deg F. Include the following:

1. Casing: Cast iron, with suction and discharge flanges of the same size for piping connections and located on a common center line 180 degrees apart for mounting in the pipe line, drain plug in bottom of volute, and threaded gage tappings at inlet and outlet connections. Flanges shall be 125 pound ANSI drilling with a casing working pressure of 175 psi. Pumps shall include a volute type casing suction branch to minimize pumping noise.

2. Impeller: ASTM B 584, cast bronze, statically and dynamically balanced, enclosed, overhung, single suction, and keyed to shaft.

3. Wearing Rings: Replaceable, bronze casing ring.

4. Shaft and Sleeve: Ground and polished steel shaft with bronze sleeve and integral thrust bearing. Include flinger on motor shaft between motor and seals to prevent liquid that leaks past pump seals from entering motor bearings.

5. Seals: Mechanical type, suitable for 250 degrees F, with all metal parts to be 303 stainless steel Viton elastomers and ceramic seat, and carbon washer. A bypass shall ber provided between the seal faces and discharge flange to assure adequate venting of the seal chamber and to provide lubrication.

6. Motor: Direct mounted to pump casing. Include lifting and supporting lugs in top of motor enclosure.

2.4 CLOSE-COUPLED, END-SUCTION PUMPS

A. Description: Centrifugal, close-coupled, end suction pumps.

B. Type: Pumps shall be horizontal mount, single stage, vertical split case and designed for 150 psi (250F) working pressure.

C. Casings shall be cast iron designed for 150 PSIG (250F) working pressure or ductile iron for working pressures above 150 PSIG and rated at 350 PSIG (250F) working pressure, any part of which can be suction pressure. Discharge nozzle shall be capable of being swiveled through any of three positions for greater flexibility of application. A separate suction cover shall be bolted to the casing and aligned with a machined lock fit. Openings shall be provided for priming, venting, draining, and for suction and discharge gauge connections. Suction and discharge connections shall be flanged, ANSI suitable for working pressures scheduled on the drawings flat faced. Casings shall be provided with renewable bronze case wear rings to maintain proper running clearance and minimize leakage between suction and discharge side of casing.

D. Shaft and Sleeve: A replaceable bronze shaft sleeve shall be furnished to cover the wetted area of the shaft extending through the seal box.

E. Bearings: Provide regreasable ball bearings with 50,000 hour life, rated L10 and dust-sealed.

F. Seals: Hot water pump shall be provided with mechanical seals of carbon ring, Viton Elastomer and ceramic stationary seats. Condenser water and chilled water shall be provided with mechanical seals of carbon ring Buna elastomer and ceramic stationary seat. Provide a flushing line from the discharge volute to the flush seal cap. For condenser water pumps, provide an abrasive separate in the flushing line. For pumps rated at working pressures above 150PSIG, mechanical seals of stainless steel with a rotating face of babbitt filled carbon and a stationary face of tungsten carbide, balanced type designed for 250 degrees F.

G. Motor: Direct mounted to pump casing. Include supporting legs as integral part of motor enclosure. Motor shall be sized for non-overloading over full characteristic curve of the pump. Motors shall be close coupled type.

H. Impellers: Provide bronze impellers, statically and dynamically balanced, of the enclosed type, machined and polished. Impellers shall be securely fastened to the shaft by key and locked shaft collar. The vanes shall be designed to reduce noise.

2.5 FRAME MOUNTED, END-SUCTION PUMPS

A. Description: Horizontally mounted, base-mounted, centrifugal, separately coupled, end-suction, single-stage, bronze-fitted, vertically split case design with flexible couplings.

B. Casings: Cast iron designed for 150 PSIG (250F) working pressure or ductile iron for working pressures above 150 PSIG and 350PSIG (250F) working pressure, any part of which can be suction pressure. Discharge nozzle shall be capable of being swiveled through any of three positions for greater flexibility of application. A separate suction cover shall be bolted to the casing and aligned with a machined lock fit. Openings shall be provided for priming, venting, draining, and for suction and discharge gauge connections. Suction and discharge connections shall be flanged, ANSI suitable for working pressures scheduled on the drawings flat faced. Casings shall be provided with renewable bronze case wear rings to maintain proper running clearance and minimize leakage between suction and discharge side of casing.

C. Shaft and Sleeve: A replaceable bronze shaft sleeve shall be furnished to cover the wetted area of the shaft extending through the seal box. The shaft shall be high strength S.A.E. 1045 steel accurately machined and of sufficient size to transmit the maximum horsepower and loading from the impeller to the bearing impeller at the maximum allowable operating speed. Shaft shall be furnished with a deflector between the casing and bearing frame to prevent leakage of the fluid into the bearings.

D. Bearings: Provide greasable ball bearings with 50,000 hour life, rated L10 and dust-sealed.

E. Seals: Hot water pump shall be provided with mechanical seals shall be carbon ring, Viton Elastomer and ceramic stationary seats. Condenser water and chilled water shall be provided with mechanical seals of carbon ring Buna elastomer and ceramic stationary seat. Provide a flushing line from the discharge volute to the flush seal cap. For condenser water pumps, provide an abrasive separate in the flushing line. For pumps with working pressures above 150 PSIG, mechanical seals shall be stainless steel with a rotating face of babbitt filled carbon and a stationary face of tungsten carbide, balanced type designed for 250 degrees F.

F. Motor: Motor shall be sized for non-overloading over full characteristic curve of the pump.

G. Impellers: Provide bronze impellers, statically and dynamically balanced, of the enclosed type, machined and polished. Impellers shall be securely fastened to the shaft by key. A self locking cap nut and compression seal washer shall be used to clamp the impeller hub firmly against the shaft sleeve to prevent leakage between the impeller and shaft. The vanes shall be designed to reduce noise.

H. Flexible Couplings: For pumps with variable speed drives and constant speed over 40HP, provide Falk type “T” steel with coupling guard. For constant speed pumps with motors less than 40HP, Woods type will be permitted.

I. Coupling Guard: Steel, removable, and attached to mounting frame.

J. Mounting Frame: Welded-steel frame and cross members, factory-fabricated from ASTM A 36 (ASTM A 36M) channels and angles. Fabricate for mounting pump casing, coupling guard, and motor. Grind welds smooth before application of factory finish. Field-drill motor-mounting holes for field-installed motors.

K. Motor: Secured to mounting frame, with adjustable alignment.

2.6 HORIZONTAL AXIAL SPLIT-CASE PUMPS

A. Description: Base-mounted, centrifugal, separately coupled, single or double-suction, single-stage, bronze-fitted, horizontally axial split case design. Shut-off head shall be 20 percent greater than operating head.

B. Casings: Casing shall be horizontally split with upper and lower halves bolted together. Flanged suction and discharge connections shall be located in the lower to allow for removal of the upper half casing for inspection of the mechanical seal and allow for removal of the entire rotating element without distributing suction or discharge piping or pump and driver alignment. Construct of close-grained cast iron, or semi-steel designed for working pressure as schedule.

C. Bearing housing seats shall be cast integrally with the casing and seats for casing wear rings, stuffing box and bearing housing shall be bored in one machine to ensure alignment.

D. The upper casing shall have taps for stuffing box seal piping priming and vents. The lower casing shall have taps for gauges and draining in the bearing arms for removal of lubricating liquid.

E. Provide threaded openings for air removal, gland sealing and drainage. Provide brass air vent cocks, and 300 pound 3/4-inch brass drain valves.

F. Pumps shall be equipped with renewable bronze case rings designed so that hydraulic pressure will seat case rings against shoulder in pump case around the full periphery of the wearing ring. The wear rings shall be locked in place by doweling to prevent rotation. Pumps with 8 inches discharge and larger shall be furnished with Bronze impeller wear rings

G. Impellers: Bronze impellers, statically and dynamically balanced, of the enclosed type, machined and polished. Impellers shall be securely fastened to the shaft by key and locked shaft collar. The vanes shall be designed to reduce noise.

H. Shafts: The pump shaft shall be made of stainless steel, accurately machined to give true running rotating element.

I. Flexible Couplings: For pumps with variable speed drives and constant speed over 40HP, provide Falk type “T” steel with coupling guard. For constant speed pumps with motors less than 40HP, Woods type will be permitted.

J. Mechanical Seals: All pumps shall be provided with mechanical seals, sediment separators and flushing systems. Seals shall be John Crane type suitable for the pressure and service schedules on the drawings. Springs shall be of stainless steel and metal parts of seal head shall be of non-rusting material (brass or stainless steel). Carbon rotating washer shall be John Crane P1 or equal. Stationary seals shall be ceramic or equal. Balance seals shall be furnished where suction pressures exceed 150 PSI with stationary seats of tungsten carbide.

Pumps shall be fitted to allow for mechanical seal replacement without removing the casing upper half.

K. Shaft Sleeves: Provide removable shaft sleeves.

1. For seal pumps use 316 stainless steel sleeves, or 416 stainless steel shafts.

L. Glands: Glands shall be of the flush type design and constructed from ductile iron. Design of gland shall insure a flush of clean treated water to the seal face by means of a 1/4" soft copper flush line from the pump discharge to the flush connection in the gland. A “John Crane” abrasive separator shall be provided for each seal and piped into the flush line to insure clean treated water to the seal face. Seal chamber shall be integral with casing top and bottom and shall be interchangeable to accept packing or mechanical seals. Pumps rated at less than 200GPM do not require sediment separators.

M. Bearings: Provide heavy duty grease lubricated ball bearings rated for 80,000 hours, drain and fill plugs, and housed in line-bored bearing brackets cast integral with lower casing. Fit with doweled and bolted bearing caps.

N. Motor: Motor shall be sized for non-overloading over full characteristic curve of the pump.

O. Coupling Guard: Steel, removable, and attached to mounting frame.

P. Mounting Frame: Welded-steel frame and cross members, factory-fabricated from ASTM A 36 (ASTM A 36M) channels and angles. Fabricate for mounting pump casing, coupling guard, and motor. Grind welds smooth before application of factory finish. Field-drill motor-mounting holes for field-installed motors.

Q. Motor: Secured to mounting frame, with adjustable alignment.

2.7 PUMP SPECIALTY FITTINGS

A. Include the following pump specialty fittings with end connections matching pump and piping.

1. Suction Diffuser: Angle or straight pattern, cast-iron body and end cap, pump-inlet fitting. Include bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory- or field-fabricated support.

2.8 GENERAL-DUTY VALVES

A. Refer to other Division 15 Sections for general-duty gate, ball, butterfly, globe, and check valves.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment foundations, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting performance of pumps.

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

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Do not proceed until unsatisfactory conditions have been corrected.

3.2 CONCRETE

A. Install concrete bases of dimensions required for pumps. Refer to Division 3 Section "Cast-in-Place Concrete" and Division 15 Section "Basic Mechanical Materials and Methods."

3.3 INSTALLATION

A. Install pumps according to manufacturer's written installation and alignment instructions.

B. Install pumps in locations indicated and arranged to provide access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so that piping is not supported by pumps.

D. Suspend in-line pumps using continuous-thread hanger rod and vibration-isolation hangers of sufficient size to support weight of pump independent of piping system.

E. Set base-mounted pumps on concrete foundation. Disconnect coupling halves before setting. Do not reconnect couplings until alignment operations have been completed.

1. Support pump base plate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches (19 to 38 mm) between pump base and foundation for grouting.

2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

F. Bedplate (Motor Drive): Cast iron, channel steel or structural steel with drip collection chamber and tapped drain connections and a large opening for grouting. Jig drilled and tapped for pumps and NEMA frame motors. On close-coupled pumps, motor assembled as integral part of the complete unit; no bedplate required. Pumps and/or pumps sets shall be leveled with tapered steel wedges to allow a minimum of 3\4 inch pump base and inertia base or concrete pad.

G. Duplex Condensate Pump Units: Install units for collection of condensate. Make connection to drainage piping, as required.

3.4 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting them on foundations, after grout has been set and foundation bolts have been tightened, and after piping connections have been made. Alignment shall be made with dial indicator to a tolerance of ±.002".

B. Comply with pump and coupling manufacturers' written instructions.

C. Adjust alignment of pump and motor shafts for angular and parallel alignment by 1 of 2 methods specified in the H.I.'s Standards for Centrifugal, Rotary & Reciprocating Pumps, "Instructions for Installation, Operation and Maintenance."

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Fill base plate completely with nonshrink, nonmetallic grout, with metal blocks and shims or wedges in place. After grout has cured, fully tighten foundation bolts.

3.5 CONNECTIONS

A. Connect piping to pumps as indicated. Install valves that are the same size as piping connecting to pumps.

B. Install suction and discharge pipe sizes equal to or greater than the diameter of pump nozzles.

C. Install electrical connections for power, controls, and devices.

D. Electrical power and connections are specified in Division 16 Sections.

3.6 FIELD QUALITY CONTROL

A. Check suction piping connections for tightness to avoid drawing air into pumps.

B. Clean strainers.

C. Check Alignment.

D. Verify that piping is not supported by pump.

E. Set pump controls.

F. Guarantee: Pump to deliver required GPM against design and within ±3% without over-heating motor, bearings or any other parts and without producing noise audible outside the space in which the pumps are installed. Certified test statements to be provided for each pumping unit. Seals to be replaced without charge if faulty operation or unusual wear occurs during guarantee period, not caused by maintenance faults.

3.7 COMMISSIONING

A. Start -up: Pumps shall be installed in accordance with the standards of the Hydraulic institute.

B. Final Checks Before Startup: Perform the following preventive maintenance operations and checks before startup:

1. Lubricate bearings.

2. Remove grease-lubricated bearing covers, flush bearings with kerosene, and clean thoroughly. Fill with new lubricant according to manufacturer's recommendations.

3. Disconnect coupling and check motor for proper rotation that matches direction marked on pump casing.

4. Check that pumps are free to rotate by hand. Pumps for handling hot liquids shall be free to rotate with pump hot and cold. Do not operate pump if it is bound or even drags slightly until cause of trouble is determined and corrected.

5. Check that pump controls are correct for required application.

6. The pump manufacturer shall check the motors and pumps for proper alignment glands for proper tightness and all bearings for proper lubrication before pumps are started.

7. The HVAC Contractor shall instruct the Testing and Balancing Subcontractor to take amperage readings on each phase of all pump motors and after 15 days Of operation the HVAC Contractor shall recheck and adjust as required alignment and gland tightness and bearing lubrication.

C. Starting procedure for pumps with shutoff power not exceeding safe motor power:

1. Prime pumps, opening suction valve, closing drains, and preparing pumps for operation.

2. Open cooling water supply valves in cooling water supply to bearings, where applicable.

3. Open sealing liquid supply valves if pumps are so fitted.

4. Open warm-up valves of pumps handling hot liquids if pumps are not normally kept at operating temperature.

5. Open circulating line valves if pumps should not be operated against dead shutoff.

6. Start motors.

7. Open discharge valves slowly.

8. Check general mechanical operation of pumps and motors.

9. Close circulating line valves once there is sufficient flow through pumps to prevent overheating.

D. When pumps are to be started against closed check valves with discharge shutoff valves open, steps are the same, except that discharge valves are opened sometime before motors are started.

E. Refer to Division 15 Section 15990 "Testing, Balancing and Adjusting" for detailed requirements for testing, adjusting, and balancing hydronic systems.

END OF SECTION 15540

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes chemical treatment systems for the following:

1. Hot-water closed heating systems.

2. Hot Water closed heating system with glycol.

3. Chilled Water closed System.

4. Steam Systems.

5. Boiler Water (H.P. Steam).

6. Boiler Water (L.P. Steam).

7. Deareator Systems.

1.2 RELATED DOCUMENTS

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

B. This section is a part of each Division 15000 Section making reference to Water treatment and cleaning and the other sections of division 15000.

1.3 SCOPE OF WORK

A. Provide, for the full construction period as well as for 2 additional years starting from the date of acceptance by Owner, complete water treatment equipment, associated piping, chemicals and service for systems as specified and/or shown on the drawings. Equipment, chemicals and service shall be provided by the independent water treatment company. That company shall supervise the installation of the chemical feed equipment, chemical cleaning of the systems and testing. Provide all necessary wiring to an adequate source of electric power, and all required interwiring.

B. Dosage and Control

1. All chemical programs must be selected for the building’s water supply, and must be adjusted so that when applied at the concentrations of active chemicals and cycles of concentration recommended by the Supplier, the programs will meet the performance requirements as specified herein.

C. It is responsibility of the Supplier to obtain and become familiar with all necessary building technical plant and operating information. Appointments must be made with facility management and engineering personnel for this purpose.

D. Daily records of all water treatment activities shall be maintained by the water treatment company and made available to the building operations personnel representing the owner. These records shall consist of all communications and test records from the water treatment company, all chemical additions, all fill and drain cycles, cleanings, additions to the piping system and any other pertinent data, starting at the first filling of the system.

E. The water treatment company shall include with service all required chemicals for testing, initial cleaning, startup treatments, test equipment and all chemicals required for the two year period during which service is rendered.

F. All service visits shall be confirmed in writing to the Owner so that complete record of service activities is available for examination by the Owner and engineer.

G. The water treatment company selected shall be responsible for insuring that all pipe systems and equipment for which they are responsible remain clean and free from all corrosion during all testing or filling and draining operations.

Under no circumstances shall raw, untreated water be introduced into these pipes and equipment or be allowed to remain in place anytime during construction. All hydronic testing shall only be with treated water at all times.

Upon completion of all building construction operations associated with the piping system in question, the system shall be cleaned by the water treatment company using appropriate chemicals which are nonaggressive to the materials in that pipe system, but which will clean surface rust, oil, grease and silt from the steel piping and other contaminants associated with the piping fabrication process.

Cooling systems shall be cleaned with an alkaline phosphate and/or detergent solution.

Chemicals for initial treatment of the water must be on-hand before cleaning is started, so that these chemicals can be added to the initial water fill after cleaning is complete. Under no circumstances shall the cleaned system be filled with untreated water or allowed to stand empty between cleaning and initial fill.

The start-up chemical treatment program shall be, at a minimum, 3-4 times the dosage of the maintenance chemical treatment program.

The cleaning operation shall be completed when agreed upon representative pipe lengths which have been in place during the entire building process have been satisfactorily cleaned as established by all interested parties.

H. At no time shall the Mechanical Contractor add water to a system without that water containing a corrosion inhibiting treatment chemical. The addition of minimal amounts of untreated water to an already treated system is allowed.

I. Hydrostatic Testing Corrosion Inhibitor

1. If sections of system must be hydrostatically tested prior to cleanout, appropriate inhibitor shall be added to the test water at sufficient level to totally passivate metal and provide protective film on pipe surfaces to prevent corrosion prior to cleanout and treatment. Mechanical Contractor shall be responsible to coordinate this treatment with the water treatment contractor.

2. At no time shall water be added to a system without that water containing a corrosion inhibiting treatment chemical.

J. All materials installed in the system such as pumps, pipe, fittings, dielectrics, relays, solenoid valves, flow switches, etc. shall have a pressure rating equal to or greater than the maximum calculated pressure expected at the installed locations.

1.4 MICROBIOLOGICAL CONTROL

A. The Supplier must provide a specific microbiological control program. Both oxidizing and non-oxidizing biocides are acceptable, along with biodispersants and other control measures. The program must list specific biocides with application dosages and frequency, and must include all of the information specified herein. Acquired immunity to one biocide must be considered.

1.5 CHEMICAL PROGRAMS

A. All chemicals provided for use in the open condenser water and all closed water systems, and for testing purposes, must meet all applicable EPA and OSHA requirement as well as all applicable federal, state and local regulations. In addition, all chemicals must meet the following criteria:

1. Toxicity

(a) Chemicals must be non-toxic to personnel and safe to handle when usual precautions are observed.

2. Disposal and Cleanup

(a) At use concentrations in the systems, all chemicals must be acceptable in the building's sewer system. The supplier must provide clear directions for cleanup of accidental chemicals spills, including necessary safety precautions, and must ensure that sufficient supplies and equipment required for cleanup of chemical spills are on hand for emergency use.

B. Furnish chemicals recommended by water treatment system company for treating water to meet specified water quality. Provide only chemicals that are compatible with piping materials, seals and all accessories.

1.6 PERFORMANCE

A. All chemical programs recommended for use in the building water and steam systems must meet or exceed the following performance guidelines.

1. Water Systems

		Open Systems	Closed Systems
(a)	Corrosion on mild steel	Less than 2.0 mpy	Less than 1.0 mpy
(b)	Pitting attack on mild steel	None	None
(c)	Corrosion on copper alloys	Less than 0.2 mpy	Less than 0.1 mpy
(d)	Scaling and deposition	None	None
(e)	Microbiological fouling	1. No visible deposits 2. No health hazards 3. Planktonic counts 4. Less than 1 x 104/ml	No visible deposits No health Hazards Planktonic counts Less than 1 x 103/ml

2. Steam Systems

		Condensate & Steam
(a)	Deposition	No detectable deposition
(b)	Corrosion	No detectable deposition
(c)	Oxygen Pitting	None
(d)	Dissolved oxygen	No detectable
(e)	Water and steam quality	As per ASME and other guidelines

B. Corrosion and Deposit Control

1. The supplier must provide a specific corrosion, scale and deposit control program for mild steel, copper alloys and any other metals present in the system. Corrosion inhibitors for each metal to be protected must be specifically identified.

1.7 CHEMICAL TREATMENT - WATER SYSTEM - DESCRIPTION

A. Chemical Treatment - Cleaning and Degreasing

The selected water treatment company shall provide a supervised program of cleaning and degreasing chemicals to be used in the specified system prior to startup. New Chillers, piping, and connected equipment shall be cleaned by circulating an alkaline product as specified by the equipment manufacturer or the water treatment company. Follow the cleaning procedure as specified in this section of the specification. All cleaning shall be in accordance with the National Association of Corrosion Engineers Recommended practice - NACE RP0182-95.

After cleaning is completed, the equipment shall be dumped, flushed with clean water and drained again and filled with water containing the correct corrosion inhibitors as supplied by the water treatment company. The initial chemical dose shall be twice the normal operating dose.

B. Chemical Treatment - Hot Water Closed Heating System

1. The water treatment company shall provide a suitable water treatment program for Closed Hot Water Systems. The program shall meet the performance requirements, as outlined above.

2. Provide a 5 gallon shot feeder including funnel, or 2" wide mouth valve opening and air relief valve for addition of chemicals to the system. Isolation valves and a low point drain shall be included in this piping system.

3. Chemical feed pumps, positive displacement type, with ball-type check valve and feed rate adjustable while pump is running. Each chemical feed pump shall have the necessary pressure rating and discharge capacity to meet system requirements.

4. The controller, sample stream piping assembly and chemical feed pumps shall be pre-piped, pre-wired and assembled on a steel wall frame. This prefabricated water treatment system will require the mechanical contractor to provide inlet and outlet water connections and 110/1/60 power to the controller and pump.

5. Coupon Rack

(a) Furnish and install in addition to corrosion spool pieces, a coupon rack to monitor chemical treatment. Coupon rack to be fabricated from 1 inch diameter black iron pipe. Do not combine coupon rack with spool piece assembly. The coupon rack shall include, as a minimum:

(1) Inlet and outlet shut-off valves and low point drain.
(2) Wye strainer.
(3) Corrosion probe connection fittings.
(4) Space for two corrosion coupons with holders.
(5) Flow meter appropriate for the desired flow range
(6) Flow control valve

(b) Placement of the corrosion coupon rack shall be at, or as near as possible, to the low point of the system. It shall be placed immediately upstream of the chemical feed injection point and shall receive the "chemically oldest" water of the system. The inlet shall be from the bottom of the corrosion coupon rack. The owner shall have the right to increase the number of coupon ports and the number of corrosion coupon racks.

(c) Corrosion coupons will be analyzed by the water treatment company responsible for those coupons and test reports provided at recommended intervals.

(d) Corrosion coupons may also be installed and analyzed by the Owner's representatives as a control on the water treatment company.

C. Chemical Treatment - Hot Water Closed Heating System with Glycol

1. In addition to the above, provide sufficient inhibited glycol for a 40% solution in the closed water system. This material shall be of a grade suitable for cooling and refrigeration systems. Automotive grade glycol is not to be used for this application. HVAC grade Dowtherm 5R-1 or equal shall be acceptable.

   HVAC grade glycol contains a complete corrosion inhibitor package and can be purchased as neat product and diluted into the system, or for small systems, it may be more convenient to purchase a ready mixed grade that can be used to fill the system without further dilution.

2. Provide a manual feed pump to introduce glycol into the system. Pump shall feed glycol from the drum with minimum capacity of 60 gph (1.0 gpm) for system pressure. Drum cradle with flexible suction and discharge hose minimum 10 ft. shall be supplied. Mechanical contractor to install hose cock at point of injection.

D. Chemical Treatment - Chilled Water Closed System

1. The water treatment company shall provide a suitable water treatment program for Chilled Water Closed Systems. The program shall meet the performance requirements, as outlined above.

2. Provide a 5 gallon shot feeder including funnel, or 2" wide mouth valve opening and air relief valve for addition of chemicals to the system. Isolation valves and a low point drain shall be included in this piping system.

3. Chemical feed pumps, positive displacement type, with ball-type check valve and feed rate adjustable while pump is running. Each chemical feed pump shall have the necessary pressure rating and discharge capacity to meet system requirements.

4. The controller, sample stream piping assembly and chemical feed pumps shall be pre-piped, pre-wired and assembled on a steel wall frame. This prefabricated water treatment system will require the mechanical contractor to provide inlet and outlet water connections and 110/1/60 power to the controller and pump.

5. Coupon Rack

(a) Furnish and install in addition to corrosion spool pieces, a coupon rack to monitor chemical treatment. Coupon rack to be fabricated from 1 inch diameter black iron pipe. Do not combine coupon rack with spool piece assembly. The coupon rack shall include, as a minimum:
(1) Inlet and outlet shut-off valves and low point drain.
(2) Wye strainer.
(3) Corrosion probe connection fittings.
(4) Space for two corrosion coupons with holders.
(5) Flow meter appropriate for the desired flow range.
(6) Flow control valve.

(b) Placement of the corrosion coupon rack shall be at, or as near as possible, to the low point of the system. It shall be placed immediately upstream of the chemical feed injection point and shall receive the "chemically oldest" water of the system. The inlet shall be from the bottom of the corrosion coupon rack. The owner shall have the right to increase the number of coupon ports and the number of corrosion coupon racks.

(c) Corrosion coupons will be analyzed by the water treatment company responsible for those coupons and test reports provided at recommended intervals.

(d) Corrosion coupons may also be installed and analyzed by the Owner’s representatives as a control on the water treatment company.

E. Chemical Treatment - Chilled Water Closed System with Glycol

1. In addition to the above, provide sufficient inhibited glycol for a 40% solution in the closed water system. This material shall be of a grade suitable for cooling and refrigeration systems. Automotive grade glycol is not to be used for this application. HVAC grade Dowtherm 5R-1 or equal shall be acceptable.

HVAC grade glycol contains a complete corrosion inhibitor package and can be purchased as neat product and diluted into the system, or for small systems, it may be more convenient to purchase a ready mixed grade that can be used to fill the system without further dilution.

2. Provide a manual feed pump to introduce glycol into the system. Pump shall feed glycol from the drum with minimum capacity of 60 gph (1.0 gpm) for system pressure. Drum cradle with flexible suction and discharge hose minimum 10 ft. shall be supplied. Mechanical contractor to install hose cock at point of injection.

3. Coupon Rack

(a) Furnish and install in addition to corrosion spool pieces, a coupon rack to monitor chemical treatment. Coupon rack to be fabricated from 1 inch diameter black iron pipe. Do not combine coupon rack with spool piece assembly. The coupon rack shall include, as a minimum:

(1) Inlet and outlet shut-off valves and low point drain.

(2) Wye strainer.

(3) Corrosion probe connection fittings.

(4) Space for two corrosion coupons with holders.

(5) Flow meter appropriate for the desired flow range.

(6) Flow control valve.

(b) Placement of the corrosion coupon rack shall be at, or as near as possible, to the low point of the system. It shall be placed immediately upstream of the chemical feed injection point and shall receive the "chemically oldest" water of the system. The inlet shall be from the bottom of the corrosion coupon rack. The owner shall have the right to increase the number of coupon ports and the number of corrosion coupon racks.

(c) Corrosion coupons will be analyzed by the water treatment company responsible for those coupons and test reports provided at recommended intervals.

(d) Corrosion coupons may also be installed and analyzed by the Owner's representatives as a control on the water treatment company.

1.8 CHEMICAL TREATMENT FEED AND CONTROL

A. Chemicals shall be supplied in bulk consistent with established safety guidelines. The Supplier shall supply all equipment required to properly feed the chemical programs and to control system operations in the ranges recommended by the Supplier for optimum performance.

B. The chemical feed and control system shall be supplied by the water treatment vendor and shall be designed to feed chemicals to the condenser water system based on blowdown (conductivity control) or make-up (water meter control) as recommended by the water treatment vendor and approved by the Owner or his representative.

With either system, the controller shall provide grounded AC receptacles for chemical treatment pumps and switched for automated or manual control of chemical feed and blowdown.

When chemicals additions are taking place, the system shall be under normal circulation conditions.

C. Air Conditioning Condenser Water System (Automatic Water Treatment Control System Without Acid Feed Less Than 100 ppm of Total Alkalinity in Make-up Water)

1. Chemical feed shall be accomplished from the low point of the system. Each chemical shall be fed from a mechanical pump which is suitable for the maximum building pressure where it is installed. Each pump shall be on an automatic controller, based on a: system make-up water demand, or b: chemical demand.

2. The water treatment chemical(s) shall be fed downstream of all sampling and corrosion coupon sample ports. The high pressure chemical feed line(s) into the building system shall be as short as possible and shall feed directly into a continuously circulating condenser water line. The positioning of these feed lines shall be such that the chemicals do not contact each other before they enter the building system. Appropriate check valves and control valves shall be installed to preclude back feeding of one chemical into another and to allow easy disassembly of the mechanisms.

3. Control panel shall be a single NEMA 12 steel enclosure, primed and painted, and shall have the following basic features, fully pre-wired.

(a) Internal wiring harnessed, color coded, clearly identified and brought to master terminal board.

(b) Grounded AC receptacles for chemical treatment pump and utility use.

(c) Main power switch and indicating lamp with door to shut off line voltage to control when adjustment or maintenance is required.

(d) Manual/Off/Auto selector switch and indicating lamp for bleedoff valve control.

(e) A selector switch for control of chemical feed from metered make-up or conductivity controller.

(f) Manual/Off/Auto selector switch for chemical treatment pump control.

(g) Conductivity controller with indicating meter.

(h) A counter and timer pulsed from a water meter with electric contactor in the make-up water supply line shall operate the chemical treatment pump to maintain the proper proportion of chemicals.

(i) One pre-wired programmable timer shall be available for controlling the feed of two biocide feed pumps.

(j) The TDS (Total Dissolved Solids) shall be monitored and controlled by a voltage regulated, linear conductivity controller. The conductivity controller shall be fully transistorized with plug-in printed circuit boards. The controller shall be linear over its full measuring range of 100 to 6,000 micromhos and shall have a built-in 20-amp heavy duty relay. Power and bleedoff status shall be displayed by indicating lights on the front panel. The controller shall be insensitive to phase angle shifts and be capable of operating with input line voltage of 95 to 130 volts, AC, without affecting accuracy.

(1) Sample stream piping assemblies, each shall be prepiped, and shall consist of one (1) conductivity probe with dual carbon elements potted in a PVC holder, mounted in a Flo-Tee, three (3) chemical injection tees, check valves, sample cock and inlet and outlet shut-off valves.

(2) Chemical feed pumps, positive displacement type, with ball-type check valve and feed rate adjustable while pump is running. Each chemical feed pump shall have the necessary pressure rating and discharge capacity to meet system requirements.

(3) The controller, sample stream piping assembly and chemical feed pumps shall be pre-piped, pre-wired and assembled on a steel wall frame. This prefabricated water treatment system will require the mechanical contractor to provide inlet and outlet water connections and 110/1/60 power to the control panel.

(k) Alarm - audible and visual alarm actuated on low or high pH is exceeded. Forced bleed until low or high pH condition is corrected.

(1) Alarm silence button.
(2) Front panel fuses.
(3) One pre-wired programmable timer shall be available for controlling the feed of two biocide feed pumps with bleed lockout.

4. Air Conditioning - Condenser Water System (Automatic Water Control System With Acid Feed; Greater Than 100 ppm of Total Alkalinity in Make-up Water)

(a) Chemical feed shall be accomplished from the low point of the system. Each chemical shall be fed from a mechanical pump which is suitable for the maximum building pressure where it is installed. Each pump shall be on an automatic controller, based on a: system make-up water demand, or b: chemical demand.

(b) The water treatment chemical(s) shall be fed downstream of all sampling and corrosion coupon sample ports. The high pressure chemical feed line(s) into the building system shall be as short as possible and shall feed directly into a continuously condenser water line. The positioning of these feed lines shall be sure that the chemicals do not contact each other before they enter the building system. Appropriate check valves and control valves shall be installed to preclude back feeding of one chemical into another and to allow easy disassembly of the mechanisms.

(c) Control panel shall be a single NEMA 12 steel enclosure, primed and painted, and shall have the following basic features, fully pre-wired:-

(1) Internal wiring harnessed, color coded, clearly identified and brought to master terminal board.

(2) Grounded AC receptacles for chemical treatment pump and utility use.

(3) Main power switch and indicating lamp with door to shut off line voltage to control when adjustment or maintenance is required.

(4) Manual/Off/Auto selector switches and indicating lamps for bleedoff control, chemical feed and acid feed with legend plates.

(5) A counter and timer pulsed from a water meter with electric contactor in the make-up water supply line to operate the chemical treatment pumps.

(6) A selector switch for control of chemical feed from metered make-up or pH controller.

(7) Conductivity controller with indicating meter.

(8) The TDS (Total Dissolved Solids) shall be monitored and controlled by a voltage regulated, linear conductivity controller. The conductivity controller shall be fully transistorized with plug-in printed circuit boards. The controller shall be linear over its full measuring range of 100 to 6,000 microhms and shall have a built-in 20 amp heavy duty relay.

Power and bleedoff status shall be displayed by indicating lights on the front panel. The controller shall be insensitive to phase angle shifts and be capable of operating with input line voltage of 95 to 130 volts, AC, without affecting accuracy.

5. The pH controller shall be an integral part of the control panel an it, too, shall be front panel mounted. It shall have these features:-

Input range . . . . 0 - 14 pH
Input Impedance . . . . Greater than 10^{13} ohms
Output . . . . 0- 10 volts
Stability . . . . Less than 0.001 pH/week

Line voltage effect . . . . 0.001% change
Limit of error . . . . Output - 1% of full scale
Limit of error . . . . Meter - 2% of full scale
Response time . . . . 1 sec. for 90% of change for typical electrode system regardless of length of transmitter cable
Input bias cable . . . . Less than 10^{12} amps 25°C
Avg. Temperature coeff . . . . 0.001 pH per °C
Humidity effects . . . . Negligible at 99% relative humidity
Ambient temperature . . . . 40°F to 140°F
Temperature compensation . . . . Automatic of fixed only
Alarm per control Single pole, single throw high or low mode-field selectable.
Contact rating . . . . 120 VAC 5 amps res.
Power requirements . . . . 90 - 132 VAC/60Hz/12 watts

6. The pH controller shall be voltage regulated and fully transistorized with adjustable High/Low contacts and indicating lamps. The controller shall be linear over its full measuring range of 0 - 14 pH. A Manual/Off/Auto selector switch indicating lamp and feed limit timer shall be provided for acid pump control, pH shall be recorded on a strip recorder.
7. When the pH of the system falls below the pH set point, the controller shall be interlocked with bleedoff valve open, the inhibitor feed pump on, the acid feed pump off and the low pH alarm on, until the situation is corrected.

8. The pH probe shall have a remote pre-amplifier coupled with it to insure that the length of the transmitter cable does not affect the response time of the accuracy of the system.

9. The chemical feed shall be controlled by either a reset timer actuated by a make-up water meter with electric contractor, or from the pH controller. The chemical feed control module shall have a pump status indicating lamp, a Manual/Off/Auto switch and a 20-amp pump relay.

10. Sufficient sample stream piping assemblies. Each shall be pre-piped and consist of one (1) conductivity probe with dual carbon elements potted in a PVC holder, mounted in a FloTee, one (1) pH flo-cell with measuring and reference electrodes, four (4) chemical injection tee's one (1) check valve, one (1) flow switch, one (1) sample cock and inlet and outlet shut-off valves.

11. Sufficient chemical feed pumps, positive dis-placement type, with ball-type check valve and feed rate adjustable while pump is running. Each chemical feed pump shall have the necessary pressure rating and PVDC, acrylic, or polyproplyene liquid handling materials with discharge capacity to meet system requirements. The acid pump shall contain the necessary materials of construction to resist corrosion from pumping sulfuric acid. Acid pump shall have 1/4" PVDC discharge connection for schedule 80 PVC piping to system and shall include PVDC acid injection nozzle with shut off valve on condenser water line.

12. The controller, sample stream piping assembly and chemical feed pumps shall be pre-piped, pre-wired, and assembled on a steel wall frame. This prefabricated water treatment system will require the mechanical contractor

to provide inlet and outlet water connections and 110/1/60 power to the control panel as well as chemical feed discharge connections and piping to the condenser water line with check valve and shut off valve at each injection point.

1.9 SERVICE PROGRAMS

A. The Supplier shall provide a complete service program to support his chemical treatment program and to protect the building water systems. The Supplier shall visit the building biweekly or as required, and shall be available for emergency service on 24 hours notice.

B. Water Testing by Building Personnel

The Supplier shall provide all field test kits and reagents required for maintaining proper control of chemical additions and operating conditions in the building water and steam systems. The supplier shall provide a Hach DR 2020 or equivalent test unit for use by building personnel. The supplier shall train building personnel in the proper testing procedures and shall supply suitable forms for recording test results. Costs for test equipment and annual costs for reagents shall be specifically identified.

1. Weekly Testing of all Closed Systems, Including Chilled Cooling Water, and Hot Water Heating Systems.

(a) pH.

(b) Corrosion inhibitor.

(c) Bioassay slide (monthly).

(d) Other tests as required by building management of the Supplier.

2. Daily Testing of Steam

(a) Codensate pH.

(b) Other tests as required by building management of the Supplier.

C. Testing by the Supplier

1. The Supplier shall perform independent tests on all water systems twice per month or as agreed with building management. The Supplier's tests shall include all tests run by building personnel plus copper, iron, copper corrosion inhibitor level in cooling systems, and dissolved oxygen in condensate water plus a steam purity check and other tests as needed. The supplier shall compare his results with building test data and prepare a report for building management after each visit. As a minimum, this report shall discuss abnormalities and variations, and highlight any actions needed to maintain good results in all systems. The supplier shall take quarterly water samples from all systems for complete chemical and microbiology analyses.

2. Inspections

(a) All condensers, surface condensers, heat exchangers, and steam systems shall be inspected annually and as available, using fiber optic and ultrasonic test equipment as needed. A photographic record shall be kept of the condition of the tubesheets, heads and accessible piping.

1.10 WATER METER

A. Water meter provided by water treatment company shall be installed on make-up water line to tower. Water meter shall have electric contact head of following size:

Up to 500 tons	3/4"	100 gallon contact
500 - 900 tons	1"	150 gallon contact
900 - 1500 tons	1 ½"	300 gallon contact
1500 - 2000 tons	2"	500 gallon contact

B.

2000 - 3000 tons	3"	750 gallon contact
Over 3000 tons	As recommended by water treatment contractor.	

1.11 CHEMICAL TREATMENT TESTING EQUIPMENT

A. Provide a complete test set with apparatus and chemical reagents for running all control tests required for the condenser water, closed water, open water system and boiler systems, as determined by the water treatment company. The test equipment shall include a wall hung metal cabinet with light, for storage of test reagents and apparatus.

1.12 DIELECTRIC FITTINGS

A. Provide dielectric fitting to isolate joined dissimilar materials to prevent galvanic action and stop corrosion. Fittings shall be of the non reducing type, which shall be suitable for the system fluid, pressure, and temperature and shall not restrict the flow.

1.13 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. As a minimum, the following information must be supplied for each chemical to be used in the building water systems:

1. Product data sheet.

2. MSD sheet.

3. Generic composition.

4. Product dosage, during startup and normal operation.

5. Concentrations of active ingredients in the circulating water.

6. Required operating parameters, e.g. pH and cycles of concentration.

7. Product cost per pound and required pounds per year.

8. Total annual program cost for chemicals, reagents and required analytical equipment.

C. In addition, submit the following for approval:

1. System installation drawings and diagrams.

2. Product information and material safety data sheets on each component, device, pump, controller, valve, etc. being supplied in the system.

3. Analysis of raw water supplying each system. Field test reports indicating and interpreting test results relative to compliance with specified requirements.

4. Product information sheets and MSD sheets on all chemical products being supplied for each system including chemicals. Include manufacturer's technical product data, rated capacities of selected equipment clearly indicated, water-pressure drops, weights (shipping, installed, and operating), furnished specialties, accessories, and installation and startup instructions.

5. Recommended feed rates on each chemical product.

6. Analysis of blow down water from each system requiring blowdown.

7. Recommended quantity of blowdown water from each system requiring blowdown.

8. Recommended operating conditions for each system including cycles of concentration, chemical test limits of water treatment system set points.

9. Shop drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

10. Wiring diagrams detailing power and control wiring and differentiating clearly between manufacturer-installed wiring and field-installed wiring.

11. Maintenance data for chemical water treatment to include in the operation and maintenance manual specified in Division 1. Include detailed manufacturer's instructions and parts list for each item of equipment, control, and accessory. Include troubleshooting maintenance guide.

12. Name of Vendor.

1.14 QUALITY ASSURANCE

A. Supplier Qualifications: A recognized chemical water treatment supplier with warehousing facilities in the Project's vicinity and that is or employs an experienced consultant, available at reasonable times during the course of the Work to consult with Contractor, Architect, and Owner about water treatment.

B. Water Treatment Suppliers must have at least five years of experience applying and servicing water treatment programs in similar type and sized buildings in the area the building is located.

C. The water treatment company shall be regularly engaged in this type of work and service. It shall have on its staff a graduate chemical engineer with experience in water treatment Further, this firm shall include the start-up of chemical treatment; instruct the Owner's operating personnel in the performance of control tests and their interpretation and to supervise, through periodic visits, the progress of the water treatment program. Such service shall be provided during construction and for two years after the Owner's acceptance for the facilities.

D. Water Treatment Suppliers must have a laboratory that is equipped and staffed to analyze water and deposit samples in accordance with standard methods. Water treatment supplier must have trained service personnel available to provide year-round service support to the building and respond to any emergency calls.

E. Chemical Standards: Meet state and local pollution-control regulations.

F. Comply with NFPA 70 for components and installation.

G. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

1.15 MAINTENANCE

A. Service Period: Provide chemicals and service program for period of two years from startup date of equipment, including the following:

1. Initial water analysis and recommendations.

2. Startup assistance.

3. Training of operating personnel.

4. Periodic field service and consultation.

5. Customer report charts and log sheets.

6. Laboratory technical assistance.

1.16 EXTRA MATERIALS

A. Chemicals: Furnish quantity equal to 50 percent of amount initially installed.

PART 2 - PRODUCTS

2.1 BIDDERS AND MANUFACTURERS

A. The following vendors will be reviewed for approval providing they meet all of the performance requirements of the specifications.

1. Betz Industrial

2. Ashland Chemical Company, Drew Industrial Division

3. Diversey Water Management.

4. Nalco Chemical Company

5. The Metro Group

6. Or engineer approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install treatment equipment level and plumb, according to manufacturer's written instructions, rough-in drawings, the original design, and referenced standards.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. The following are specific connection requirements:

1. Install piping adjacent to equipment to allow servicing and maintenance.

2. Piping: Conform to applicable requirements of Division 15

B. Electrical: Conform to applicable requirements of Division 16

1. Provide all necessary wiring to an adequate source of electric power and all required interwiring.

2. Install electrical devices furnished with boiler but not specified to be factory mounted.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Provide the services of a qualified independent testing agency to perform field quality-control testing.

3.4 ADJUSTING

A. Sample boiler water at 1-week intervals after boiler startup for a period of 5 weeks and prepare certified test report for each required water performance characteristic. Where applicable, comply with ASTM D 3370 and the following standards:

1. Silica: ASTM D 859.

2. Steam System: ASTM D 1066.

3. Acidity and Alkalinity: ASTM D 1067

4. Iron: ASTM D 1068.

5. Water Hardness: ASTM D 1126.

6. Particulate and Dissolved Matter: ASTM D 1888.

B. Sample system water for each system at 1-week intervals after startup for a period of 5 weeks and prepare certified test report for each required water performance characteristic.

3.5 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed parts and finish. Remove burrs, dirt, and construction debris; repair damaged finishes, including chips, scratches, and abrasions.

B. At no time shall the Mechanical Contractor add water to a system without a corrosion inhibitor treatment. The addition of minimal quantities of untreated water to a satisfactorily treated system is allowed.

C. Ensure that system is operational, filled, started, and vented prior to cleaning. Place terminal control valves in OPEN position during cleaning. Use water meter to record capacity in each system.

D. Add cleaning chemicals as recommended by manufacturer.

1. Hot-Water Heating System: Apply heat while circulating, slowly raising system to design temperature; maintain for a minimum of 12 hours. Remove heat and allow to cool; drain and refill with clean treated water. Circulate for 6 hours at design temperature, then drain. Refill with clean treated water and repeat until system cleaner is removed.

2. Chilled-Water System: Circulate for 48 hours, then drain. Refill with clean

treated water, circulate for 24 hours, then drain. Refill with clean treated water and repeat until system cleaner is removed.

3. Steam System: Fill steam boilers only with cleaner and treated water. Apply heat and maintain for a minimum of 12 hours. Cool and drain. Refill with clean treated water, drain, refill, and check for sludge. Repeat until system is free of sludge. Apply heat to produce steam for piping system and maintain for a minimum of 8 hours. Bypass traps and waste condensate.

4. Open System: Flush with clean treated water for a minimum of one hour. Drain completely and refill.

3.6 COMMISSIONING

A. Startup Services: Provide the services of a factory-authorized service representative to provide startup service and to demonstrate and train Owner's maintenance personnel as specified below.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Startup Procedures: During boiler system startup, operate boiler water treatment system (after charging with specified chemicals) to maintain required steady-state characteristics of feedwater.

3.7 REPORTING REQUIREMENTS

A. In addition to the regular service reports specified above. The Supplier shall prepare a quarterly report for building management. This report shall contain a summary of routine test results, corrosion coupon and microbiological tests results, projects, accomplished during the preceding quarter, and specific action recommendations to correct any abnormal conditions in the water systems. The analytical data should be presented in graphical form for easy visualization and recognition of trends. Annual review meetings may also be scheduled by building management as desired.

3.8 DEMONSTRATION

A. Provide services of supplier's technical representative for a full day to instruct Owner's personnel in operation, maintenance, and testing procedures of water treatment systems.

B. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Review data in the operation and maintenance manuals. Refer to Division 1 Section "Contract Closeout."

D. Schedule training with Owner, through the Architect, with at least 7 days' advance notice.

END OF SECTION 15545

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. This section includes the design performance criteria, refrigerants, controls and installation requirements for the Electric Driven Refrigeration equipment and ancillary equipment.

1.02 RELATED DOCUMENTS

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

B. Section 15010 - Basic Mechanical Requirements.

C. Section 15050 - Basic Materials, Methods and Requirements (Mechanical).

D. Section 15942 - Variable Frequency Controllers.

E. This section is a part of each Division 15000 Section.

1.03 REFERENCES (Latest Editions)

A. ARI Standard 550/590 Centrifugal or Rotary Water Chilling Packages

B. ARI 575.

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

D. ANSI/ASHRAE 90A - Energy Conservation in New Building Design.

E. ASME Boiler and Pressure Vessel Code.

F. NEC.

G. OSHA, as adopted by the state.

1.04 QUALITY ASSURANCE

A. Company specializing in manufacture of refrigeration machines with ten years minimum experience.

B. Chiller performance shall be rated in accordance with ARI Standard 550/590 (latest edition).

C. Chiller shall be manufactured in accordance with ANSI/ASHRAE 15 (latest edition) Safety Code for Mechanical Refrigeration.

D. Chiller shall be designed and constructed to meet applicable UL requirements and shall bear the U.L. label. The entire chiller package shall be U.L. Listed.

E. Chiller shall be manufactured in a facility which has been registered by Underwriters' Laboratories, Inc. (UL) to the International Organization for Standardization ISO 9002 Series Standards for quality.

F. Cooler and condenser shall include ASME "U" stamp and nameplate certifying compliance with ASME Section VIII, Division 1 code for unfired pressure vessels. A manufacturer's data report is required to verify pressure vessel construction adherence to ASME vessel construction requirements. Form U-1 or U-3 as required per ASME code rules is to be furnished to the owner. The U-Form must be signed by a qualified inspector, holding a National Board Commission, certifying that construction conforms to the latest ASME Code Section VIII, Div. 1 for pressure vessels. The ASME symbol "U" or "UM" must also be stamped on the heat exchanger. Vessels specifically exempted from the Scope of the Code must come with material, test, and construction methods certification and detailed documents similar to ASME U-1; further, these must be signed by an officer of the company.

G. Compressor impellers shall be dynamically balanced and over-speed tested by the manufacturer at a minimum of 120% design operating speed. Each compressor assembly shall undergo a mechanical run-in test to verify vibration levels and oil pressures and temperatures are within acceptable limits. Each compressor assembly shall be proof tested at a minimum 232 psig (1600 kPa) and leak tested at 270 psig (1276 kPa) with a tracer gas mixture. The leak test shall not allow any leaks greater than 0.5 oz/year of refrigerant.

H. Entire chiller assembly shall be proof tested at 232 psig (1600 kPa) and leak tested at 270 psig (1276 kPa) with a tracer gas mixture on the refrigerant side. The leak test shall not allow any leaks greater than 0.5 oz/year of refrigerant. The water side of each heat exchanger shall be hydrostatically tested at 1.5 times rated working pressure.

I. On chillers with unit mounted compressor motor starters, chiller and starter shall be factory wired and tested together to verify proper starter operation prior to shipment.

J. Chillers shall be capable of operating and/or running @ 60°F entering condenser water temperature.

K. All electrical fitting connections shall be watertight.

1.05 VERIFICATION OF CAPACITY AND EFFICIENCY FACTORY RUN-IN TEST

A. Each chiller shall undergo a series of factory tests to ensure that the unit is leak tight, that all electrical components operate as intended, and that every aspect of unit fabrication meets stringent quality standards in accordance with good practice and the manufacturer's quality assurance requirements. Chiller shall be assembled in factory and tested in the factory.

B. Final performance tests shall be witnessed by Owner's Representative, this contractor, CM and Engineer. All costs associated with the attendance of the Owner, CM and Engineer shall be borne by the chiller Manufacturer. The costs associated with the attendance of this contractor shall be borne by this Contractor.

C. The chiller (each unit) shall be factory performance tested under full and partial load (25%, 50%, AND 75%) conditions in an ARI certified test facility. The manufacturer shall supply a certified test report to confirm performance as specified. Proper ARI certification documents for the test loop shall be made available for inspection. The performance test shall be conducted in accordance with ARI Standard 550/590 procedures and tolerances be zero tolerance.

The performance test shall be run with clean tubes in accordance with ARI 550/590 to include the following:

1. A downward temperature adjustment to the design leaving evaporator water temperature to adjust from the design fouling to the clean tube condition.

2. An upward temperature adjustment to the design entering condenser water temperature to adjust from the design fouling to the clean tube condition.

3. There shall be no exceptions to conducting the performance test with clean tubes and with temperature adjustments above. The manufacturer shall clean tubes, if necessary, prior to test to obtain a test fouling factor of .00025 hr. sq. ft. F/BTU for condenser and cooler is 0.0001 hr sq. ft. F/BTU.

4. Performance test shall be performed with the following conditions:

   (a) Design parameters (design conditions), as shown on the schedule.

(b) Entering condenser water temperature of 60°F @ 25% and 50% load.

D. Compressor assembly shall be run tested at the factory. Vibrations hall not exceed 0.14 (inch per second) at the compressor housing.

E. The factory test instrumentation shall be per latest edition ARI Standard 550/590 and the calibration of all instrumentation shall be traceable to the National Institute of Standards Technology (formerly NBS).

F. A certified test report of all data shall be submitted to the Owner prior to shipping. The factory certified test report shall be signed by an officer of the company from the manufacturer. Preprinted certification will not be acceptable; certification shall be in the original.

G. The equipment will be accepted if the test procedures and results are in conformance with ARI Standard 550/590 for zero tolerance. If the equipment fails to perform within allowable tolerances, the manufacturer will be allowed to make necessary revisions to his equipment and retest as required. The manufacturer shall assume all expenses incurred by the owner or his representatives to witness the retest.

H. The chiller automated controls test shall be executed to check for proper wiring and ensure correct controls operation. Provide demonstration of BACnet interface of all chiller data.

1.06 SUBMITTALS

A. Submit the following according to the Conditions of the Contract and as specified in Division 1 Section “Submittals” and Division 15000.

B. Provide product certified data which shall indicate capacities, accessories, ratings, performance data, sound data, motor electrical characteristics, finishes of materials and wiring diagrams.

C. Provide manufacturer's technical data for each model indicated, including rated capacities of selected model clearly indicated; dimensions; required clearances; shipping, installed, and operating weights; furnished specialties; accessories; and installation and startup instructions.

D. Include product description, list of materials for each service, and locations.

E. Submit manufacturer's installation instructions. Indicate rigging, installation and start-up procedures.

F. Submit Drawings shall detail the following: equipment assemblies, components, dimensions, weights and loadings, required clearances, and location, size, and type of field connections. Indicate equipment, piping and connections, valves, and strainers required for a complete system.

G. Provide wiring diagrams which detail wiring for power supply. Detail ladder-type wiring diagrams for interlock, signal, and control systems. Differentiate between manufacturer-installed and field-installed wiring.

H. Manufacturer's Performance Data: Indicate energy input versus cooling load output from 15 to 100 percent of full load.

I. Start-up Reports: Indicate results of startup and testing requirements. Submit copies of checklists.

J. Provide interconnecting wiring diagrams, installation details, power requirements, hardware, points lists and other software for the interface to the BMS. Refer to BMS interface section for details.

1.07 DELIVERY, STORAGE AND HANDLING

A. Unit shall be stored and handled in accordance with manufacturer's instructions.

B. Unit shall be shipped with all refrigerant piping and control wiring factory installed.

C. Unit shall be shipped charged with a nitrogen holding charge. The initial charge of refrigerant and oil will be supplied, shipped in containers and cylinders for field installation. Refrigerant shall be stored by the manufacturer, until requested for delivery by Contractor.

D. Rigging: Refrigeration machine shall be fully assembled and charged. Units field charged shall be pressure tested at the factory and charged, at the site, by the manufacturer. Machines requiring disassembly for rigging shall be factory assembled and pressure tested. Disassembly, reassembly in the field with new gaskets, pressure testing shall be by this Contractor and supervised by the manufacturer's representative and charging with refrigerant shall be by the manufacturer.

E. Unit shall be shrink wrapped at the factory prior to shipment with the lugs lifting expose. Unit shall be provided with waterproof protection for outdoor storage.

F. Unit shall be shipped with firmly attached labels that indicate name of manufacturer, chiller model number, chiller serial number, and refrigerant used.

G. Manufacturer's representative shall be on site for delivery of each unit, unit set, and float units to verify that such operations meets manufacturer's requirements, and shall indicate such approval in writing.

1.08 OPERATION AND MAINTENANCE DATA

A. Operation and Maintenance Data: Submit maintenance data and parts list for each unit, including “trouble shooting” maintenance guide, servicing guide and preventative maintenance schedule and procedures. Include this data in the maintenance manuals. Provide ten (10) copies of the O&M manuals.

B. Provide all updated field memorandum and revision, changes, issued between O&M submittal and final acceptance of the machines by Owner.

C. Warranties: Special warranties specified in this Section.

D. Include start-up: instructions, operations and maintenance data.

E. Start-up: Manufacturer shall furnish factory representative to supervise erection, testing, evacuation, dehydration, charging and starting of the machines, including owner instruction.

1.09 WARRANTY

A. Manufacturer shall provide a full parts and labor warranty for a period of three (3) years from date acceptance by the owner. In addition, the compressor, compressor motor and drive train shall carry a 5 year parts guarantee. Manufacturer must maintain a local full time parts and service company capable of responding to service needs within 24 hours.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The following vendors will be reviewed for approval providing they meet all of the performance requirements of the specifications.

1. Carrier Corp.
2. York International
3. Trane Company
4. McQuay.

2.02 ELECTRIC DRIVEN CENTRIFUGAL REFRIGERATION MACHINES

A. Each unit shall be factory assembled, single piece and the unit shall be furnished complete with lubrication system, condenser, evaporator, motor, compressor, refrigerant charge, oil charge, purge for low pressure systems and pump-out storage system for servicing, control panel and vibration pad isolators. Each chiller must provide specified tons as minimum without exceeding specified KW. Each chiller must be certified in accordance with ARI Standard 550/590, latest Edition.

B. Compressor:

1. One centrifugal compressor of the high performance, single-stage or multi-stage type. Connections to the compressor casing shall use O-rings instead of gaskets to reduce the occurrence of refrigerant leakage.

2. The open type impeller with machined shroud contours and impeller diameter optimize each compressor efficiency for each specified application. Impellers to be fabricated from high strength aluminum alloy balanced both statically and dynamically.

3. A tunnel diffuser shall provide a highly efficient controlled diffusion ratio by means of individually contoured, machined-in channels of circular cross section.

4. Compressor, motor, and transmission shall be hermetically sealed into a common assembly and arranged for easy field servicing. Internal compressor parts are accessible for servicing without removing the compressor base from the chiller. Connections to the compressor shall be flanged or bolted for easy disassembly. Compressor shall be direct driven or gear driven by squirrel cage induction type motor nameplated in accordance with NEMA standard. Compressor motor shall be liquid refrigerant cooled. Compressor assembly shall be run tested at the factory. Vibration shall not exceed 0.14 IPS (inches per second) at the compressor housing.

5. Journal bearings shall be of the steel-backed, babbitt -lined type.

6. The high speed shaft thrust bearing shall be of the tilting pad, multi-shoe, Kingsbury type with individually replaceable shoes. The low speed shaft thrust bearing shall be of the tapered land type.

7. Transmission shall be single ratio, single helical, parallel shaft speed increaser. Gears shall conform to AGMA Standards.

8. The compressor design shall include a balancing piston to offset impeller thrust forces. The gear thrust load shall act opposite to impeller thrust loads.

9. The **[variable frequency drive (VFD)],** shall provide capacity modulation from 100% to 15% capacity, with 2.5°F (1.38°C) drop in entering condenser water temperature per 10% capacity reduction.

10. The inlet guide vanes shall provide pre-whirl of the refrigerant vapor entering the impeller for more efficient compression at all loads.

11. Compressor shall be provided with a factory installed lubrication system to deliver oil under pressure to bearings and transmission. Provisions shall be included to control temperature of the oil by heating and cooling the oil to maintain proper oil temperature. Included in the system shall be:

    (a) Hermetic motor-driven variable speed oil pump with factory installed motor contactor with overload protection.

    (b) Oil reservoir, designed and stamped in accordance with ASME of applicable pressure vessel code.

    (c) Auxiliary reservoir to provide lubrication during coastdown in the event of a power failure.

    (d) Refrigerant-cooled oil cooler, with service valves.

    (e) Oil pressure regulator.

    (f) Twenty-micron oil filter with isolation valves to allow filter change without removal of refrigerant charge.

    (g) Oil sump heater controlled from unit microprocessor.

    (h) Oil reservoir temperature sensor with main control center digital readout.

    (i) Oil pump and motor.

    (j) Provide factory mounted compressor motor starter wiring to oil pump, oil heater, and controls shall be pre-wired in the factory and power shall be applied to check proper operation prior to shipment.

12. Compressor shall be fully field serviceable. Compressors which must be removed and returned to the factory for service shall be unacceptable.

13. Acoustical attenuation shall be provided as required, to achieve a maximum (full load or part load) sound level of [88] dBA, measured per ARI Standard 575 (latest edition). Attenuation shall be provided by the manufacturer and shall be easily removed and reinstalled.

C. Motor:

1. Compressor motor shall be of the hermetic liquid refrigerant cooled, squirrel cage, induction type suitable for voltage shown on the equipment schedule.

2. Motor design speed shall be 3550 rpm (60 Hz) or 2950 rpm (50 Hz).

3. Motors shall be suitable for operation in a refrigerant atmosphere and shall be cooled by atomized refrigerant in contact with the motor windings.

4. Motor stator shall be arranged for service or removal with only minor compressor disassembly and without removing main refrigerant piping connections.

5. Full load operation of the motor shall not exceed nameplate rating.

6. One motor winding (with one spares) temperature sensor shall be provided.

7. Low voltage motors (600 v or less) shall be suitable for connection to solid-state type reduced voltage starters **[or to VFDs]**.

D. Cooler and Condenser:

1. Cooler and condenser shall be of shell and tube type construction, each in separate shells. Units shall be fabricated with high-performance tubing, steel shell and tube sheets with fabricated steel waterboxes.

2. Tubing shall be copper, high-efficiency type, with integral internal and external enhancement. Tubes shall be nominal 3/4-in. OD with nominal wall thickness of 0.035 in. measured at the root of the fin. Tubes shall be rolled into tube sheets and shall be individually replaceable. Tube sheet holes shall be double grooved for joint structural integrity. Intermediate support sheet spacing shall not exceed 36 in. (914 mm).

3. The cooler and condenser shells shall be bolted together to allow for field disassembly and reassembly. Tube sheets shall be welded into the shell.

4. The vessel shall display an ASME nameplate which shows the pressure and temperature data and the "U" stamp for ASME Section VIII, Division 1. Double pressure relief valves shall be installed on each heat exchanger. A safety rupture disc and relief valve assembly in accordance with latest edition ANSI/ASHRAE safety code shall be provided for the refrigerant circuit. Contractor shall provide piping to atmosphere conforming with code (with braided hose connection). Condenser and evaporator must conform to the ASME code for unfired pressure vessels and stamped.

5. Condenser and evaporators 1000 tons and greater shall be provided with marine type water boxes with removable gasketed steel plate box covers exposing all tubes for cleaning without disturbing water piping connections. Machine below 1000 ton capacity shall be furnished with standard water box with groove nozzles. Waterboxes shall be nozzle-in-head type with stubout nozzles having Victaulic grooves to allow for use of Victaulic couplings.

6. Waterboxes and nozzle connections shall be designed for **[150]** psig minimum working pressure. Waterboxes shall have vents, drains, and covers to permit tube cleaning within the space shown on the drawings.

7. A thermistor type temperature sensor shall be factory installed in each water nozzle.

8. Cooler shall be designed to prevent liquid refrigerant from entering the compressor. Devices that introduce pressure losses (such as mist eliminators) shall not be acceptable because they are subject to structural failures that can result in extensive compressor damage.

9. Tubes shall be individually replaceable from either end of the heat exchanger without affecting the strength and durability of the tube sheet and without causing leakage in adjacent tubes.

10. The condenser shell shall include a Flash Subcooler which cools the condensed liquid refrigerant to a reduced temperature, thereby increasing the refrigeration cycle efficiency.

E. Refrigerant Flow Control:

1. To improve part load efficiency, liquid refrigerant shall be metered from the condenser to the cooler using a float-type metering valve to maintain the proper liquid level of refrigerant in the heat exchangers under both full and part load operating conditions. By maintaining a liquid seal at the flow valve, bypassed hot gas from the condenser to the cooler is eliminated. The float valve chamber shall have a bolted access cover to allow field inspection and the float valve shall be field serviceable. Fixed orifices shall be unacceptable. Refrigerant flow shall be controlled to allow chiller to start and operate continuously with condenser water down to 60°.

F. Refrigerant Storage and Pumpout System

1. Individual Pumpout Units:

(a) A refrigerant storage system shall be installed on each chiller. The pumpout unit shall use a semi-hermetic reciprocating compressor with water cooled condenser. Condenser water piping, 3-phase motor power, and 115-volt control power shall be installed at the jobsite by the installing contractor. The refrigerant storage vessel shall be either integral to the machine, (cooler or condenser shells shall be large enough to hold the entire refrigerant charge) or freestanding (storage tank with all interconnecting piping). Pumpout shall be factory mounted on the chillers. Compressor discharge isolation valve and liquid line ball shall be factory installed on each chiller to allow isolation of the refrigerant charge in the condenser or cooler for servicing the chiller.

2. Units without an integral storage vessel shall have a freestanding refrigerant storage tank and pump out systems complete with transfer pump, condensing unit and tank. The storage vessels shall be designed and constructed in accordance with ASME code (Section VIII Division 1 with 300 psig (2068 kpa) design pressure) for unfired pressure vessels and with the National Board Stamp. The storage vessels shall be vertical in type.
The system (pump, refrigerant storage tank, etc.) shall be sized to handle a single chiller's refrigerant capacity.

The tank shall include a liquid level gage and pressure gage. Pump-out system is used to remove and store refrigerant from the centrifugal machine. Piping between pump-out and chiller and wiring for the pump to be supplied and installed by installing contractor.

Contractor shall provide all piping, electrical equipment, and wiring required. Refrigerant piping shall be type K hard-drawn copper with wrought copper fittings. Double relief valves per ANSI/ASHRAE 15 latest edition. Valves shall be packless type suitable for refrigerant use.

If one pump-out system shall serve multiple machine installations pump-out system shall have capacity to service the largest chiller.

3. Relief valves are to vent to atmosphere, vent piping is by this contractor.

2.03 CONTROLS (COORDINATE WITH BMS CONTRACTOR)

A. Controls, Safeties, and Diagnostics:

1. Controls:

(a) The chiller shall be provided with a factory installed and wired microprocessor control center with individually replaceable modular component construction. Components included shall be the main processor/input-output module, chiller control module, power supply, starter management module (located in the starter cabinet), relay board, and temperature and pressure (thermistor and transducer) sensors. The control center shall include a 16 line by 40 character liquid crystal display, 4 function keys, stop button, and alarm light. The microprocessor can be configured for either English or SI units. The chiller control system shall interface and communicate directly via BACnet to the building management system without the use of additional field-installed hardware or software.

Chiller microprocessor shall be connected to the BMS system by others. The BMS system shall receive data required for integrated chiller plant control. Chiller microprocessor control panel shall be provided with BACnet or Conformance Class 3 Controller to allow full control and monitor chiller operation from BMS. If the chiller manufacturer cannot provide each chiller with a BACnet Conformance Class 3 Controller, the manufacturer shall provide an interface panel to translate all chiller data into BACnet compliant data with read and write options. Refer to ASHRAE Standard 135-1995 for details.

(b) The default standard display screen shall simultaneously indicate the following minimum information:

(1) Date and time of day.

(2) 24 character primary system status message.

(3) 24 character secondary status message.
(4) Chiller operating hours.

(5) Entering chilled water temperature.

(6) Leaving chilled water temperature.

(7) Evaporator refrigerant temperature.

(8) Entering condenser water temperature.

(9) Leaving condenser water temperature.

(10) Condenser refrigerant temperature.

(11) Oil supply pressure.

(12) Oil sump temperature.

(13) Percent motor Rated Load Amps (RLA).

(14) Number of Starts/Runtime hours, % Rated Load/Phase.

The default screen shall be displayed if there is no manual activity at the control console for 15 minutes.

(c) Any additional wiring required to meet the control and monitoring requirements of this specification shall be the responsibility of the manufacturer.

(d) The 4 function keys shall be software driven within the Status, Schedule, Set Point and Service menu structures (as described below):

(1) Status Function:

In addition to the default screen, status screens shall be accessible to view the status of every point monitored by the control center including:

(i) Evaporator pressure.

(ii) Condenser pressure.

(iii) Bearing oil supply temperature.

(iv) Compressor discharge temperature.

(v) Motor winding temperature.

(vi) Number of compressor starts.

(vii) Control point settings.

(viii) Discrete output status of various devices.

(ix) Compressor motor starter status.

(x) Spare input channels (16).

(2) Schedule Function:
The chiller controls shall be configurable for manual or automatic start-up and shut-down. In automatic operation mode, the controls shall be capable of automatically starting and stopping the chiller according to a stored user programmable occupancy schedule. The controls shall include built-in provisions for accepting a minimum of two 365-day occupancy schedules. Each schedule shall allow a minimum of 8 separate occupied/unoccupied periods, any or all of which can be scheduled by individual day for any or all days of the week, with a separate schedule for holidays.

Schedules shall allow specification of Daylight savings start/end and up to 18 user-defined holidays up to one year in advance (month, day, and duration in days). Display of the occupancy schedules shall be viewable on the LCD screen. Each schedule shall provide a means of configuring an occupancy timed override to permit a "one time extension" of an occupied period on the configured day. The controls shall also provide for chiller start-up and shutdown via remote contact closure from a customer supplied device or from a building management system software command.

(3) Set Point Function:

The controls shall provide the capability to view and change the leaving chilled water set point, entering chilled water set point, (both primary and secondary) condenser water temperature, and demand limit set point at any time during chiller operating or shutdown periods. The controls shall allow for the specifications of capacity control by either leaving chilled water or entering chilled water.

(4) Service Function:

The controls shall provide a password protected service function which allows authorized individuals to:

(i) View and alarm history file which shall contain the last 25 alarm/alert messages with time and date stamp. These messages shall be displayed in text form, not codes.

(ii) Execute a chiller controls test function for quick identification of malfunctioning components.

(iii) View/modify chiller configuration.

(iv) View/modify chiller occupancy periods.

(v) View/modify schedule holiday periods.

(vi) View/modify schedule override periods.

(vii) View/modify system time and date.

(5) Network Window Function

Each Chiller control panel shall be capable of viewing multiple point values and status's from other like controllers connected on a common network, including controller maintenance data. The operator shall be able to alter the remote controller's set points or time schedule and to force point values or status's for those points that are operator forcible. The control panel shall also have access to the alarm history file of all like controllers connected on the network.

(6) Capacity control shall be by means of a variable inlet guide vanes located at the impeller inlet. Load modulation shall be from 100% to 15% of compressor full load under normal ARI conditions without the use of hot gas bypass. The guide vanes are precisely positioned by a PID (proportional-integral-derivative) control algorithm to ensure precise control (+ .5° F [+ .3 ° C]) of desired chilled water temperature without hunting or overshooting the set point.

(7) The microprocessor control system shall include a programmed sequence to meet prelube needs prior to machine start-up and during coast down after machine stop. The microprocessor shall automatically activate and interlock the chilled water pump, condenser water pump, and cooling tower fans upon chiller activation.

(8) Upon request to start the compressor, the control system shall start the chilled water pumps condenser water pumps and

tower fans and verify that flows have been established. The controller shall then compare the entering/leaving chilled water temperature with the chilled water set point. If the chilled water temperature is less than the chilled water set point, the control system shall shut down the condenser water pump and wait for the cooling load to be established.

(9) A user-configurable ramp loading rate, effective during the chilled water temperature pulldown period, shall control the rate of guide vane opening to prevent a rapid increase is compressor power consumption. The controls shall allow configuration of the ramp loading rate in either degrees/minute of chilled water temperature pulldown or percent motor amps/minute. During the ramp loading period, a message shall be displayed informing the operator that the chiller is operating in ramp loading mode.

(10) The control system shall include 2 compressor cycle timers to protect the motor from rapid cycling, a 15 minimum start-to-start timer, and a 1 minute minimum stop-to-start timer. In addition, the compressor shall be inhibited from restarting if more than 8 manual starts within a 12 hour period have occurred, unless manually reset to override the start count.

(11) The control system shall automatically cycle the compressor off to minimize energy usage whenever the leaving chilled water temperature is 5 ° F (3° C) below the desired chilled water set point. The chilled water pump shall remain on and when the leaving chilled water temperature rises above the set point by a user-configured amount, the compressor shall automatically restart. During the shutdown period, a message shall be displayed informing the operator a recycle restart is pending.

(12) The control system shall monitor line voltage and if loss of voltage, high or low line voltage, or single cycle dropout is sensed, the chiller shall shut down. Upon restoration of line voltage, if the auto-restart after power failure algorithm is enabled, the chiller shall automatically resume the mode of operation functioning prior to shutdown. No additional wiring shall be required.

(13) The reset of the chilled water temperature set point based on any one of the following criteria:

(i) Chilled water reset based on an external 4 to 20 mA signal or BACnet interface to BMS.

(ii) Chilled water reset based on a remote temperature sensor (such as outdoor air).

(iii) Chilled water reset based on water temperature rise across the evaporator.

When reset is active, a message shall be displayed indicating the type reset in effect.

The BMS system shall be capable of a reset function which shall apply to the entire chiller plant. When reset is active, a message shall be displayed indicating the type reset in effect.

(14) The control center shall limit amp draw of the compressor to the rated load amps or to a lower value based on one of the following criteria:

(i) Demand limit based on a user input ranging from 40% to 100% of compressor rated load amps.

(ii) Demand limit based on external 4 to 20 mA signal. When demand limit is active a message shall be displayed indicating the source of the demand signal.

(15) The controls shall be capable of being configured to soft stop the compressor. When the stop button is pressed or remote contacts open with this feature active, the VFD shall reduce motor speed to a configured amperage level and the machine shall then shut down. The display shall indicate "shutdown in progress."

2. Safeties:

(a) Evaporator freeze protection override shall be provided by load limiting when low evaporator pressure/temperature is detected before tripping the low refrigerant safety. Surge protection shall be provided. When a unit is operating in surge an alert shall be signaled. If the surge condition is not corrected within 15 minutes, the chiller shall be shut down.

(b) Unit shall automatically shut down when any of the following conditions occur: (Each of these protective limits shall require manual reset and cause an alarm message to be displayed on the LCD screen, informing the operator of the shutdown cause.)

(1) Motor overcurrent.

(2) Over voltage*.

(3) Under voltage*.

(4) Single cycle dropout*.

(5) Bearing oil high temperature.

(6) Low evaporator refrigerant temperature.

(7) High condenser pressure.

(8) High motor temperature.

(9) High compressor discharge temperature.

(10) Low oil pressure.

(11) Prolonged surge.

(12) Loss of cooler water flow.

(13) Loss of condenser water flow.

(14) Starter fault.

* Shall not require manual reset or cause an alarm if auto-restart after power failure is enabled.

(c) The control system shall detect conditions which approach protective limits and take self-corrective action prior to an alarm occurring. The system shall automatically reduce chiller capacity when any of the following parameters are outside their normal operating range:

(1) High condenser pressure.
(2) High motor temperature.

(3) Low evaporator refrigerant temperature.

(4) High motor amps.

During the capacity override period, a pre-alarm (alert) message shall be displayed informing the operator which condition is causing the capacity override. Once the condition is again within acceptable limits, the override condition shall be terminated and the chiller shall revert to normal chilled water control. If during either condition the protective limit is reached, the chiller shall shut down and a message shall be displayed informing the operator which condition caused the shutdown and alarm.

(d) Diagnostics and Service:

(1) The control system shall execute a series of prestart checks whenever a start command is received to determine if pressures, temperatures, and timers are within pre-start limits, thereby allowing start-up to proceed. If any of the limits are exceeded, a text alert message will be displayed informing the operator of the cause of the pre-start alert. Provide BACnet Data to BMS to transmit text alert message.

(2) A self diagnostic controls test shall be an integral part of the control system to allow quick identification of malfunctioning components. Once the controls test has been initiated, all pressure and temperature sensors shall be checked to ensure they are within normal operating range. A pump test shall automatically energize the chilled water pump, condenser water pump, and oil pump. The control system shall confirm that water flow and oil pressure have been established and require operator confirmation before proceeding to the next test. [A guide vane actuator test shall open and close the guide vanes to check for proper operation prior to proceeding to the next test. The operator manually acknowledges proper guide vane operation prior to proceeding to the next test.]

(3) In addition to the automated controls test, the controls shall provide a manual test which permits selection and testing of individual control components and inputs. A thermistor test and transducer test shall display on the LCD screen the actual reading of each transducer and each thermistor installed on the chiller.

(4) All sensors shall have quick disconnects to allow replacement of the sensor without replacement of the entire sensor wire. Pressure transducers shall be capable of field calibration to ensure accurate readings and to avoid unnecessary transducer replacement. Transducers shall be serviceable without the need for refrigerant charge removal or isolation.

(e) Building Control System Interface:

The chiller control system shall interface and communicate directly to the BMS via BACNET. All data (sensors, setpoints, schedules) shall be transmitted to the BMS via BACnet.

(f) Multiple Chiller Control by BMS System

The local chiller controls shall be supplied as an integral part of the units to control each chiller in the plant. The BMS shall automatically start and stop a lag or second chiller on the chiller system. If one of the chillers on line goes into a fault mode, the next chiller shall be automatically started. The chiller lead/lag system shall allow manual rotation of the lead chiller, include load balancing if configured, and a staggered restart of the chillers after a power failure. BMS shall be complete with required input/output to control all the chillers on a common loop, condenser water system and secondary loop pumps. The liquid crystal display specified for the chiller micro-processor shall be the only operator interface required to program, modify, change, enable, or disable the Local Chiller Control System. The BMS shall provide:

(1) Automatic lead/lag control of chillers based on system load

(2) Lead/lag switching based on runtime, fixed rotation, calendar date, and/or outside air temperature.

(3) Capability to customize sequence for unequal sized chillers.

(4) Capability to designate a chiller to perform “feathering functions”

(5) Capability to start next available chiller in event of chiller alarm

(6) Capability to perform chilled water system reset based on outdoor air temperature chilled water system differential temperature or return chilled water temperature.

(7) Control of pumps, towers, valves and variable frequency drives via input/output modules.

(8) Interface to building demand meter for demand limiting via the Loadshed Module.

(9) Data logging for chiller operating parameters.

(10) Optimize the chiller plant operation based on building cooling load, energy costs, water temperature, cooling loads, etc.

The chiller microprocessor shall be capable of interfacing with a BMS operator workstation. The PC shall include the ability to annunciate alarms, display dynamic graphics of the chiller plant, and display chiller plant reports. The chiller microprocessor shall be capable of communicating via BACnet to other vendor supplied control devices as required for data logging, demand limiting, air side interface, and other control functions.

If a building automation and control system is supplied by other than the chiller manufacturer, the supply of additional communications interface hardware and software shall be the responsibility of the chiller manufacturer.

The chiller manufacturer shall provide all field testing, programming and commissioning labor as required for each chiller. All data shall be verified by the chiller manufacturer between the chiller and BMS system (BACnet). The chiller manufacturer shall provide all point "maps" to BMS contractor as required. The chiller manufacturer shall provide all labor as required to participate in integrated commissioning and testing.

(f) The control shall provide the following:

(11) Automatic lead/lag control of chillers based on system load

(12) Lead/lag switching based on runtime, fixed rotation, calendar date, and/or outside air temperature.

(13) Capability to customize sequence for unequal sized chillers.

(14) Capability to designate a chiller to perform "feathering functions"

(15) Capability to start next available chiller in event of chiller alarm

(16) Capability to perform chilled water system reset based on outdoor air temperature chilled water system differential temperature or return chilled water temperature.

(17) Control of pumps, towers, valves and variable frequency drives via input/output modules.

(18) Interface to building demand meter for demand limiting via the Loadshed Module.

The chiller management system shall optimize the chiller plant performance based on building cooling load, energy costs water temperatures and chiller sizes.

2.04 INSULATION

A. Insulation of the evaporator economizer low side, motor shell, motor cooling lines and the suction connection to the compressor shall be designed and installed to prevent sweating of all cold surfaces. The insulation shall include removable sections for the evaporator water boxes and economizer chamber where applicable and meet all existing codes. This insulation will be field furnished and installed by contractor as recommended by manufacturer.

2.05 TOOLS

A. Manufacturer shall supply any special tools required for normal operation and servicing of equipment.

2.06 FACTORY-INSTALLED FEATURES

A. The following shall be factory installed.

1. Reduced Voltage Unit Mounted Starter:

Variable frequency drive will be supplied as specified in Division 15 Section “Variable Frequency Controllers.”] [Reduced voltage solid-state starter shall be supplied as specified in Division 15 Section “Enclosed Motor Controllers”.

The compressor motor starter shall be factory mounted, wired and tested prior to shipment by the chiller manufacturer. Electrical connection for compressor motor power shall be limited to main power leads to the starter, wiring of the cooler and condenser flow switches to the chiller control circuit, and wiring water pumps and tower fans to the chiller control circuit. Included in the UL and CSA approved starters are:

(a) NEMA 1 enclosure with integral fan cooling and lockable hinged door.

(b) Main power disconnect (non-fused type).

(c) Starter Management Module (SMM) which communicates with the chiller control system to perform starting and stopping of the chiller, water pumps, and tower fans, as well as monitoring starter operation. Included in this module is a single cycle dropout protection.

(d) Microprocessor based, 3-phase, overload relay with manual reset.

(e) 3 kva control/oil heater transformer.

(f) Branch circuit breaker for oil pump.

(g) Branch circuit breaker for control power and oil heater.

(h) 10 pilot relays for control of chilled water pump, condenser water pump, tower fan, customer remote alarm, and main power disconnect shunt trip.

(i) The starter shall include the following standard motor protection features:

(1) Phase loss.

(2) Phase reversal

(3) Phase imbalance

(4) 3-phase ground fault
Low voltage - phase to phase and phase to ground
Medium voltage - phase to ground

(5) Current overload

(6) Current flow while stopped

(7) 3-phase under/over voltage

(8) 3-phase digital ammeter/voltmeter
(9) Microprocessor based overload trip

(j) Starter shall also provide the following monitoring:

(1) Watts

(2) Power factor

(3) Frequency

(4) Watt demand

(5) Watt hour

The starter shall be provided with factory mounted circuit breaker with current limiting fuses, or with a current limiting circuit breaker. Operating handle and trip indicator shall be located in the door.

Ground fault protection shall be provided with indication of ground fault provided in the starter. Reset capability shall be provided in the starter. The starter shall be provided with distribution fault protection which shall take the compressor motor off line if a momentary voltage failure, or "deep" dip occurs in the electrical service, and be able to automatically restart the motor when the fault is corrected and without damaging the motor. The distribution fault protection shall consist of three-phase current sensing and monitoring devices which shall be capable of detecting distribution faults of 1½ (one and a half) electrical cycles duration and disconnecting the compressor motor within 6 (six) electrical cycles. In addition the starter shall incorporate under voltage protection and phase failure protection, both of the field adjustable time delay type. Ammeter, voltmeter and switches that allow reading of all three phases shall be provided. The ammeter shall be calibrated so that inrush current can be indicated in addition to operating current. The starter shall be provided with a U.L. label attesting to its series connected short circuit rating for faults up to 100,000 amperes.

Starter shall be factory mounted or field mounted and wired including all control wiring. If a field mounted starter is furnished, installation and all required wiring shall be provided by the installing contractor.

PART 3 - EXECUTION

3.01 INSTALLATION AND START-UP

A. Handle and install units in accordance with instructions and recommendations of the manufacturer.

3.02 FIELD-INSTALLED ACCESSORIES

A. All accessories specified herein, shall be installed by this contractor.

B. Sound Insulation Kit:

Unit manufacturer shall furnish a sound insulation kit that covers the compressor housing, motor housing, compressor discharge pipe, condenser shell, and suction line. If not met the required noise level as required by the acoustic consultant.

1. Inner and outer jacket construction shall be 17 oz. Sq. Yd PTFE Teflon impregnated fiberglass cloth.

2. Insulation material shall be 11 lb/cu. ft. fiberglass needles materials with Barium Sulfate loaded vinyl acoustic barrier.

3. Blanket construction shall be double sewn and lock stitched with minimum of 7 stitches per inch using Teflon-coated, fiberglass thread. All raw jacket edges shall have a trifold Teflon cloth binding. No raw cut edges shall be exposed.

4. Insulation design shall accommodate temperature and pressure probes, gages, tubing, piping, and brackets.

5. To avoid penetrating noise at mating seams, blanket pieces shall include an extended 2-in. wide vinyl flap. This flap shall cover all exposed seams, thereby minimizing any potential noise leaks.

6. An aluminum nameplate shall be riveted to each blanket piece. Each tag shall be embossed or etched with lettering indicating piece location, description, size and tag number sequence.

7. To enhance blanket quality and maintain uniform thickness, stainless steel quilting pins shall be placed at random locations no greater than 18 in. a part to prevent shifting of the insulation filler.

C. Discharge Line Sound Reduction Kit:

1. Unit manufacturer shall furnish a discharge line sound reduction kit that completely covers the compressor discharge pipe and reduced compressor noise, of not met the required noise level as required by the acoustic consultant.

D. Flow Switch

1. Manufacturer shall supply and contractor shall install flow detection devices (United Electric 24-013H2012R or equal) in chilled water and condenser water piping. Switches shall make contact when flow is established. Flow switches shall be installed in horizontal runs at least 5 pipe diameters downstream from any bend or tee.

E. Electrical Requirements:

1. Electrical power shall be supplied to the unit at the voltage, phase, and frequency listed in the equipment schedule by the Electrical trade.

2. Power supplies shall be individually fused and shall include the control circuit, oil pump system circuit, oil heater circuit, purge circuit and pumpout condensing unit.

3. Electrical contractor shall wire between free standing starter (or VFD) and chiller.

4. BMS contractor shall wire the water flow switches to the chiller control circuit to ensure that the chiller will not operate until flows are established and maintained.

5. BMS contractor shall wire the chilled water pump, condenser water pump, and tower fan control circuit to the chiller control circuit.

6. BMS contractor shall supply and install all electrical wiring and devices required to interface the chiller controls with the building control system.

F. Piping Requirements - Instrumentation and Safeties:

Mechanical contractor shall supply and install pressure gages and thermometers in readily accessible locations in piping adjacent to the chiller such that they can be easily read from a standing position on the floor. Gages shall be Marsh Master or equal with 4 1/2 in. nominal diameter face. Scale range shall be such that design values shall be indicated at approximately mid-scale.

Gages shall be installed in the entering and leaving water lines of the cooler and condenser for each chiller.

G. Vibration Isolation:

Provide neoprene isolator pads for mounting equipment on a level concrete surface.

3.03 REFRIGERANT MONITORING SYSTEM (COMPLETE CHILLER PLANT)

A. Furnish a refrigerant monitoring system, within the refrigeration plant to monitor for refrigerant leaks from each of the chillers (electric, steam turbine and future). The refrigerant monitoring system shall employ photo-acoustic technology to provide sensing capability to one part per million (ppm), and shall be UL certified to accurately distinguish between different compounds. Refrigerant monitoring system, shall be manufactured and installed in compliance with ASHRAE Standard 15-2001 equipment room guidelines.

B. The accuracy of the refrigerant monitor shall be certified per UL 2075 and CSA 22.2.

C. Provide for the mounting of the monitoring panel within the room and the remote mounting of the remote interface panel up to 250 feet away from the refrigeration plant.

D. Scanners and panels shall permit sensing of up to three different locations (for each chiller) within the refrigeration plant. The system shall utilize a multi-channel scanner to monitor each sensor location and provide a method for setting the zero reference point.

E. The sensing devices shall be located on each chiller and within the refrigeration plant, as per the manufacturer's recommendations. Provide 3 sensing devices for each chiller, as well as 4 additional sensors to be located at low points within the chiller plant, as per the manufacturing recommendations.

F. The system shall be provided with a remote reset switch, located outside the plant. The alarm shall be reset only after the refrigerant is cleared.

G. Provide an alarm horn, strobe light and silence switch at each entrance to the plant, above the break glass switch. Alarm to activate when leak occurs. Horn shall be silenceable from switch and strobe shall continue to operate until condition is cleared.

H. Provide emergency power to system.

I. The refrigerant monitoring system shall include contacts to start the MER purge ventilation system, activate local and remote alarms and shutdown chillers in the alarm mode. Coordinate with chiller manufacturer.

J. The refrigerant monitoring system shall integrate directly with the BMS system (coordinate with BMS contractor). Provide dry contacts for transmitting alarms to BMS.

K. Refrigerant monitors shall be factory calibrated for the specific compound utilized.

L. All wiring for the refrigerant monitoring system including all controls, alarm devices, annunciators, switches, remote panels, etc. shall be by the **[BMS] [this]** contractor.

3.04 SELF-CONTAINED BREATHING APPARATUS

Provide and install six OSHA approved self contained OSHA approved breathing apparatuses in accordance with ASHRAE 15-2001.

A. The SCBA shall comply with all of the requirements of the National Institute for Occupational Safety and Health (NIOSH) and the American National Standards Institute (ANSI) and the National Fire Protection Association (NFPA-1981).

B. The SCBA shall be warranted by the manufacturer for a period of five years.

C. The SCBA shall not weigh more than 22.5 lbs, be easy to use, comfortable to wear. Charts and a VHS video shall be available for user training.

D. The SCBA face piece shall have provision for an optional face cup. The face cop will prevent fogging of the face piece when the SCBA is used in cold areas.

E. The SCBA shall have a speaking diaphragm allowing for short range communications with optional provisions for a microphone in the face piece to interconnect with a portable radio.

F. The SCBA shall be equipped with a pressure regulator having a true independent bypass system with a quick acting mainline valve for instant airflow. The valve shall be belt mounted for convenient positioning and maintenance.

G. The SCBA shall have a formed carrier and support harness which is flame and heat resistant, steel reinforced for durability and with retro-reflective coatings and markings.

H. The SCBA shall be equipped with a cylinder having a 60-minute rating.

I. The SCBA shall be equipped with a loud bell that sounds when the SCBA air pressure reaches 540 psig. This feature allows enough air to allow a user to leave the danger area.

J. The SCBA shall be stored in a yellow fiberglass wall case. The case will keep the SCBA clean, visible and ready to use in an emergency.

K. Mount each cabinet on the wall just outside all the chiller room entrances. Each cabinet shall be labeled "SELF-CONTAINED BREATHING APPARATUS FOR EMERGENCY USE".

3.05 START-UP SERVICES

A. Manufacturer’s Supervision: A factory-trained service representative of the manufacturer shall be on site to supervise the field-assembly (if any), final installation, pressure testing, checkout, and start-up and testing of controls for each chiller by this contractor as outlined in the start-up operation and maintenance manual provided by the chiller manufacturer and as specified herein. Prepare manufacturer’s written report/log of the installation and start-up signed by the service representative and the Owner.

1. Representative shall supervise leak testing, evacuation, dehydration, and charging of oil and refrigerant. If any chiller is found to have lost its shipping pressure prior to the time of installation and assembly, then the machine shall be leak tested, and shall be evacuated a minimum of 24 hours. Other special provisions for unit testing and setup as recommended by the equipment manufacturer shall also be followed.

2. Representative shall perform start-up procedures recommended by the manufacturer.

3. Representative shall also be on site to assist the BMS contractor with the set-up, installation, coordination and operation of the refrigeration plant BMS controls system.

B. Sustained Operation: Do not place the chiller in sustained operation prior to initial balancing of the mechanical systems affected by chiller operation.

C. Manufacturer's representative shall perform start-up procedures recommended by the manufacturer.

D. After the above services have been performed, the same factory-trained representative shall be available for a period of classroom instruction for a minimum 40 hours to instruct the owner's personnel in the proper operation and maintenance of the chiller.

E. Manufacturer shall supply the following literature:

1. Start-up, operation and maintenance instructions.

2. Installation instructions.

3. Field wiring diagrams.

4. Five (5) complete sets of certified drawings.

3.06 FIELD PERFORMANCE TEST

A. The test shall be performed by an independent testing company, commissioned by the chiller manufacturer, with the assistance of this contractor, under the supervision of the manufacturers representative.

B. Perform tests and submit reports. Perform tests during the cooling season when sufficient load will be available. Demonstrate that the equipment performs as specified. Record data according to equipment numbers on the drawings. Prior to the test, submit a copy of testing procedures.

C. Submit a copy of certification of the recalibration test of all instruments to be utilized for the test.

D. Test Procedure:

1. After each refrigeration unit has been started and run satisfactorily, the factory-trained specialist in conjunction with the independent testing company shall perform tests to verify efficiency, and the ability to provide rated output.

2. Submit certified report of test data to the Owner and the Engineer. The warranty period shall begin upon completion of the above submission to the satisfaction of the Owner.

   (a) This Independent testing company shall provide all instrumentation required for the performance of the efficiency and capacity tests.

3. In accepting this Contract, the water chilling unit manufacturer shall guarantee their water chilling units to give capacities not less than the capacities specified with the conditions as specified and will take whatever steps are necessary to meet the guarantee, at no additional cost to the Owner, regardless of the extent of the revisions required.

3.07 OPERATION AND MAINTENANCE INSTRUCTIONS

A. Perform in accordance with Section 01300, SUBMITTALS.

3.08 SCHEDULE

A. See drawings. (Chiller's Performance Schedule).

END OF SECTION 15651

SECTION 15747 – GROUND HEAT EXCHANGER (GHEX)

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. GHEX design and piping.

1.2 SUMMARY

A. The GHEX contractor shall comply with IGSHPA Standard as well as all State and local regulations pertaining to the installation.

B. The GHEX contractor is responsible for all aspects involved with the complete GHEX design and installation. All materials, drilling, excavation, hauling of backfill, pumping, soil compaction and labor required shall be included in the bid price.

1.3 SUBMITTAL

A. Before GHEX construction begins, the GHEX contractor must submit certified and stamped shop drawings by a Licensed Engineer to the design engineer. The shop drawings shall include all applicable manufacturer's specifications, warranties, and material safety data sheets for all materials used in the geothermal installation.

1. Submittal shall include following parameters

a. Geological formation thermal conductivity assumption with notes regarding source of assumption (i.e., recent thermal response tests in same region).

b. Geological formation thermal diffusivity assumption with notes regarding source of assumption (i.e., recent thermal response tests in same region).

B. The Owner requires drilling of 500 ft deep and 6" diameter geothermal wells with quantity as indicated on the drawings. This shall be considered the base bid. For any alternate file construction consisting of shallower wells and/or a lesser quantity of wells, the bidder must provide a deductive alternate per foot of bore depth (drilling, tubing, and testing) and or per bore deleted. Overall field must meet the capacities as indicated on the drawings.

B. Alternate designs for the GHEX may be submitted to the engineer of record for approval. Alternate designs must meet the criteria for performance and documentation as described in this section.

1. Alternate designs for the GHEX may include variations in borehole quantity, center-to-center borehole spacing, borehole depth, borehole loop pipe material, and construction method.

2. The performance of alternate designs shall be demonstrated by the GHEX contractor and shall be demonstrated using a computer simulation program. The computer simulation thermal analysis shall, at a minimum, meet the following requirements:

   a. The simulation environment must be designed to model thermal interactions between the earth and the geothermal-based HVAC system. This simulation tool must be approved by the EOR.

   b. The building loads must be applied to the proposed GHEX configuration in the simulation environment. The engineer of record is responsible to provide these loads in one of two forms:

      1) Hourly coil load data for each conditioning coil in the building will be provided in CSV or in a format compatible with Microsoft Excel.

      2) Alternatively the cumulative and peak monthly cooling and heating loads can be provided in CSV or in a format compatible with Microsoft Excel.

   c. The simulated GHEX must be accurately represented by the simulation tool including borehole construction, depth, spacing, and total quantity.

   d. The simulation shall be capable of modeling compressor efficiencies within 10% of the equipment selected. The simulation shall also reflect the contribution of supplemental heating and cooling equipment (boilers and fluid cooler) that tie into the geothermal loop. The model shall calculate the temperature of fluid entering the HVAC equipment.

   e. The simulation shall be capable of providing as an output the hourly fluid temperatures over one year and monthly maximum and minimum temperatures over a simulation period of 15-years.

3. Acceptable performance for alternate designs shall be defined as:

   a. Fluid temperature supplied to heat pumps shall not be less than 30 degrees F for the hourly fluid temperatures over one year and monthly minimum temperatures over a simulation period of 15-years..

   b. Fluid temperature supplied to heat pumps shall not be greater than 90 degrees F for the hourly fluid temperatures over one year and monthly maximum temperatures over a simulation period of 15-years.

4. The GHEX contractor shall provide to the engineer of record the parameters of the alternate design and the results of the simulation analysis. Results shall included, at a minimum, the hourly fluid temperatures over one year and monthly maximum and minimum temperatures over a simulation period of 15-years.

1.4 QUALITY ASSURANCE

A. The GHEX contractor must have on this project a certified IGSHPA installer. The GHEX contractor performing this work must have a minimum of two years experience in performing underground closed circuit ground loop work of this project's size or larger.

B. Vertical heat exchanger (VHE) fabricators must be heat fusion certified by an authorized high density polyethylene (HDPE) pipe manufacturer's representative of the brand of pipe used. Certification must include: successful completion of a written heat fusion exam as well as demonstrating proper heat fusion techniques under the direct supervision of the authorized HDPE pipe manufacturer's representative.

PART 2 - PRODUCTS

2.1 PIPE

A. The following vendors will be reviewed for approval providing they meet all of the performance requirements of the specifications

1. Chevron Philips
2. Vanguard
3. Plecxo
4. Centennial Plastics
5. ISCO Industries
6. MuoviTech
7. Or approved equal

B. The pipe shall be PE4710 HDPE with a minimum cell classification of 45434C per ASTM D3035-93 and a SDR11 (160 psi) rating for u-bends and header pipe 2 inches or smaller and a minimum of DR15.5 (110 psi) for header pipe greater than 2 inch in diameter. This pipe will carry a warranty of no less than 50 years.

1. Tubing shall be 2-pipe, U-tube configuration.
2. Tube diameter shall be 1-1/4 in.
3. Tubing shall have operating pressure rating of 200 psi.

4. Piping minimum thermal conductivity shall be 0.24 Btu/h·ft·°F.

5. Tubing shall be capable of operating at temperatures from 20°F to 120°F.

6. Internal pipe roughness shall be 0.00028” or less.

7. Average coefficient of thermal expansion (longitudinal) shall be maximum 0.001in/ ft·°F.

C. Each pipe shall be permanently indent marked with the manufacturer's name, nominal size, pressure rating, relevant ASTM standards, cell classification number and date of manufacture.

D. All piping used for VHE will have factory hot-stamped lengths impressed on the side of the piping indicating the length of the VHE at that point. The length stamp shall read zero on one end and the actual VHE total length on the other end.

2.2 PIPE INSULATION

A. Pipe insulation must be designed for underground applications. For pipe diameter’s equal to or greater than 2” the minimum wall thickness is one half (1/2) inch. For pipe diameters smaller than 2” the minimum wall thickness is one quarter (1/4) inch. Acceptable insulation type shall be closed cell polyethylene per ASTM C1427.

2.3 TEST POINT

A. A test point will be installed between immediately prior to point where the system mains exit the building. The test point will be the location where the loopfield flow test, and the loopfield and the building flush out will be done. All valves and piping will be sized to match the piping of the loop field.

2.4 FITTINGS

A. Pipe fittings shall meet the requirements of ASTM D2683 (for socket fusion fittings) or ASTM D3261 (for butt/saddle fusion fittings). Each fitting shall be identified with the manufacturer's name, nominal size, pressure rating, relevant ASTM standards and date of manufacturer.

2.5 BORE GROUT

A. Grout shall be neat cement or cement-sand mix of non-shrink, low permeability (rating of less than 1 x 10-7 cm/sec) type, with minimum thermal conductivity of 0.85 Btu/h·ft·°F. Sand type, moisture content and grain size must be approved by grout manufacturer and be demonstrated by contractor.

B. Grout shall be ANSI/NSF STD 60 certified and meet all U.S. EPA, Minnesota Department of Health, and all local requirements.

C. Bentonite grout mixtures shall be permitted only where allowed by U.S. EPA, Minnesota Department of Health, and all local requirements.

2.6 LOCATING TAPE

A. Locating tape must be foil backed, two inches wide or greater, with a continuous message printed every 36 inches or less reading: "CAUTION GEOTHERMAL PIPELINE BURIED BELOW". The tape shall be highly resistant to alkalis, acids, and other destructive agents found in the ground.

2.7 FIELD LOCATION

A. The four outside grid bores should be surveyed after drilling is complete, but before horizontal trenching is done

PART 3 - EXECUTION

3.1 DRILLING

A. All drilling techniques and methods will meet local and state codes for closed-loop geothermal drilling.

B. The vertical boreholes shall be drilled to a depth that allows complete insertion of the VHE to its specified depth. The maximum borehole diameter shall be six and one-half inches nominally. If a larger diameter is required, it must be approved by the design engineer.

C. The drilling equipment shall be able to drill through consolidated bedrock formations.

D. All permanent casing shall be schedule 40 steel installed and sealed into bedrock. Temporary casing may be installed according local and state closed-loop geothermal drilling codes.

3.2 DRILLING SPOILS AND PROCESS FLUIDS

A. There shall be adequate drilling spoils management equipment on site while drilling to handle predictable spoils and drilling fluid volumes. All drilling spoils and fluids shall be contained within piping systems, confined exaction pits and/or construction dumpsters or settling tanks in order to maintain a clean and safe work site.

B. Drilling spoils and excavated material not recycled on site shall be hauled away by a licensed waste hauler according to local regulations.

C. Water used or brought to the surface during drilling operations shall not run-off the site or be discharged to sewers or storm drains without written approval from the general contractor. If necessary filtration equipment shall be used.

3.3 U-BEND PIPE ASSEMBLY

A. U-bend assembly shall have integrated concrete and HDPE weight for overcoming buoyancy and for protection of u-bend fitting during installation. If necessary, an iron (sinker) bar can be attached at the base of each u-bend to overcome buoyancy. This iron bar will have all sharp edges adequately taped to avoid scarring and/or cutting of the polyethylene pipe. No driving rod that is pulled out after u-bend insertion will be allowed. The entire u-bend pipe assembly is inserted to the specified depth in the borehole.

3.4 GROUTING PROCEDURE

A. The VHE is to be grouted from the bottom up, in a continuous fashion, using an HDPE tremie pipe. The tremie pipe will be pulled out during the grouting procedure maintaining the pipe's end just below grout level within the borehole. All State regulations will be met for borehole grouting of the VHE. The VHE shall be filled with water pressurized and capped during the grouting procedure and for 6 hours minimum afterwards before releasing pressure on the loop.

3.5 HEAT FUSION and ELECTRO-FUSION PIPE JOINING

A. All underground pipe joining will be heat fused or electro-fused by socket, butt or saddle (sidewall) fusion in accordance to ASTM D2610, ASTM D2683 and the manufacturer's heat fusion or electro-fusion specifications. The operator shall be heat fusion or electro-fusion certified and experienced in executing quality fusion joints.

3.6 EXCAVATION AND BACKFILLING FOR PIPING

A. The GHEX contractor shall do all excavating, backfilling, shoring, bailing and pumping for the installation of his work and perform necessary grading to prevent surface water from flowing into trenches or other excavations. Sewer lines shall not be used for draining trenches unless written approval has ben granted by the general contractor. All pipe and conduit ends shall be kept sealed and lines left clean and unobstructed during construction. Only material suitable for backfilling shall be piled a sufficient distance from banks of trenches to avoid overloading. Unsuitable backfill material shall be removed as directed by the design engineer.

B. A layer of fine (FA-2 or FA-6) or coarse aggregate (CA-7) shall be installed to a minimum six inch depth around all HDPE piping, unless noted otherwise.

C. Sheathing and shoring shall be done as necessary for protection of work and personnel safety. Unless otherwise indicated, excavation shall be open cut except for short sections. The GHEX contractor shall install geothermal locating tape at least 18 inches above all horizontal/header piping.

D. Prior to drilling or trenching, the GHEX contractor shall be responsible for reviewing with the general contractor the location of underground utilities. Existing utility lines uncovered during excavation shall be protected from damage during excavation and backfilling.

3.7 PIPE INSTALLATION

A. The u-bend pipe ends will be sealed with fusion caps or tape prior to insertion into the borehole. Reasonable care shall be taken to ensure that the GHEX pipe is not crushed, kinked, or cut. Should any pipe be damaged, the damaged section shall be cut out and the pipe reconnected by heat fusion.

B. The VHEs must be connected as indicated on the plans. The header design accounts for balanced flow as well as flushing and purging flow rates. No variations can be made in the circuit hookup or the pipe sizes that are indicated without approval from the design engineer. The minimum bend radius for each pipe size shall be 25 times the nominal pipe diameter or the pipe manufacturer's recommendations, whichever is greater. The depth of all headers and supply and return piping is indicated on the plans and must be maintained.

3.8 TESTING AND CLEANING

A. Cleaning

1. During installation, all debris, and small animals shall be kept out of the pipe. Ends of the HDPE pipe shall be sealed until the pipe is joined to the circuits.

B. Flushing and purging

1. Each supply and return circuit shall be flushed and purged with a water velocity of two feet per second. The lines shall be left filled with clean water and then pressure tested. If connection to the manifold is not immediate, piping must be capped. The GHEX contractor must coordinate with the mechanical contractor on propylene glycol antifreeze installation. The mechanical contractor is responsible for the final % of propylene glycol antifreeze. See mechanical specifications for antifreeze.

C. Pressure testing

1. At a minimum, the following pressure tests shall be conducted during installation. If leaks are observed, they must be fixed prior to sign off.

a. Prior to insertion into the borehole each VHE shall be filled with water, purged of air, and pressurized to 100 psi. A visual examination of the piping under constant pressure is required. If no leaks are observed a pressure test log form must be signed before the VHE can be inserted into the borehole.

b. Prior to backfill, all horizontal piping smaller than 2" in diameter shall be filled with water, purged of air and pressurized to 100 psi. A careful visual examination of the piping is required. If no leaks are observed a pressure test log form must be signed before the backfill process may commence.

c. Prior to back fill, all horizontal piping 2" and larger shall be pressure tested as follows: Apply 70PSI max air pressure to each header pipe to easily observe leaks. Examine header connections and piping for leaks. Any header piping with leakage must be repaired and retested.

d. Prior to final completion, the entire GHEX field shall undergo an expansion based pressure tested in compliance with the recommended hydrostatic pressure test in the Plastic Pipe Institute's *Handbook of Polyethylene Pipe*.

1) Verify that the entire system has been flushed and free of all entrained air.
2) Verify the header supply and return ports are sealed or closed.
3) Verify that each borehole loop is open to the header lines.
4) Once the tank, solution and pumping assembly are setup, increase the pressure on the system to the test pressure and isolate the system under this pressure.
    a) Allow the system to expand for 1 hour.
    b) On hourly intervals for 4 hours, carefully add solution into the system as necessary to raise the system back up to the test pressure.
    c) Do not allow the system to depressurize while make-up water is added to the system.
    d) After 4 hours carefully decrease the pressure by 10 PSI and note the time.
    e) After 1 hour record the pressure and note the time.
    f) If the measured pressure is within 5% of the test pressure minus 10 PSI, leakage is not indicated.

END OF SECTION 15747

SECTION 15748 – GEOTHERMAL PERFORMANCE MONITORING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section defines the functional requirements for and **Additive Alternate** Geothermal Measurement and Verification (Geothermal M&V) system.

B. The Geothermal M&V system shall in collect data from the geothermal-based Heating Ventilation and Air Conditioning (HVAC) system, transmit data to a remote database, performs calculations, and allow real-time access to data from a web user interface for the purposes of:

1. Summarizing the performance of the geothermal system
2. Ensuring ongoing geothermal capacity
3. Displaying sensor values and rates of heat exchange
4. Quantifying energy savings in real time
5. Sending messages to system users automatically
6. Displaying user-configurable data histories
7. Exporting user-configurable data histories
8. Enabling remote control and adjustment of relevant geothermal HVAC equipment
9. Transmitting data to a third party, via an Application Programming Interface (API)

C. The Geothermal M&V system shall transmit data to a remote web server, via the owner's internet connection, and may communicate with a Direct Digital Control (DDC) system (also referred to as Building Automation System or Building Management System).

D. The Geothermal M&V system shall consist of hardware and software components and may include:

1. An electrical enclosure containing a microprocessor and web server

2. A remote data repository or repositories

3. A remote web server or servers

4. Computer code for executing the functions described herein

E. Approved Providers for the Geothermal M&V system:

1. Indie Energy Systems Company
1020 Church Street
Evanston, IL 60640
(312) 625-5599 x 4
www.indieenergy.com

2. Or engineer approved equal

1.2 RELATED SECTIONS

A. Section 15747 Ground Heat Exchanger

B. Section 15950 HVAC Instrumentation and Controls

C. Section 15951 Sequence of Operations

1.3 SUMMARY OF WORK

A. The Geothermal M&V system contractor shall provide the system components as required for executing the features and functions defined by this Section, including but not limited to:

1. Microprocessors and web servers, if not provided by the DDC contractor, for interpreting and transmitting geothermal HVAC system data to a remote data repository.

2. An NEMA rated electrical enclosure, as required, for housing microprocessors and web servers.

3. A remote data repository (database), capable of efficiently receiving, storing, and accessing data from the geothermal HVAC system.

4. A remote web server or web servers capable of managing data transmissions and requests, serving a web user interface, and performing calculations.

B. The Geothermal M&V system contractor shall provide design documents, computer software programs, and configurations as required for executing the features and functions defined by this Section, including but not limited to:

1. Design of the Geothermal M&V system, including mathematical descriptions of system performance for quantifying energy savings in real time.

2. Software for interpreting, transmitting, receiving, and storing data.

3. A web user interface.

C. The Geothermal M&V system contractor shall coordinate with the DDC contractor to commission and test the interconnection between the DDC system and the Geothermal M&V system.

1.4 EXCLUSIONS

A. The Geothermal M&V system contractor shall not be responsible for the following; these shall be provided in other scopes of work:

1. Mounting the Geothermal M&V electrical enclosure, if applicable (to be installed by DDC contractor)

2. Sensors (to be supplied and installed by DDC contractor and/or mechanical contractor)

3. Analog-to-digital converter and transmitter hardware (to be supplied and installed by DDC contractor)

4. Low-voltage wiring (to be supplied and installed by DDC contractor)

5. Network communication wiring (to be supplied and installed by DDC contractor)

6. Line-voltage wiring (to be supplied and installed by electrical contractor)

7. Internet connectivity with static internet protocol (IP) address and port forwarding configurations (to be supplied by facility owner unless otherwise indicated)

8. Commissioning of mechanical systems and control systems (to be completed by others)

9. Configuration of DDC data points to be read, including:

    a. Discovering sensors and equipment

    b. Configuring and testing sensor ranges

    c. Supplying correct sensor names, descriptions, units of measure, tags, etc.

    d. Documenting configurations

1.5 QUALITY ASSURANCE

A. The Geothermal M&V system provider shall provide a Service Level Agreement (SLA) which guarantees 99% monthly uptime for the web interface, and less than one hour of missing data per month**.**

B. The Geothermal M&V contractor shall be available to support the DDC contractor during installation and configuration of the Geothermal M&V system and shall respond to coordination requests in a timely fashion.

PART 2 - PRODUCTS

2.1 WEB SERVER

A. For installations where the Geothermal M&V contractor requires a supervisory controller to be installed on site, the hardware shall be capable of:

1. Communication with the DDC system via the Tridium Niagara Framework or a standard building automation protocol (BACnet, Modbus, LON, etc.).

2. Communication with analog-to-digital converters/controllers.

3. Transmitting data to the remote web server and remote data repository.

4. Receiving data from a remote web server.

2.2 ELECTRICAL ENCLOSURE

A. For installations where the Geothermal M&V contractor requires hardware to be installed on site, the hardware shall be installed in an NEMA-rated electrical enclosure and shall include a lock to prevent unauthorized access to electrical devices.

2.3 REMOTE DATA REPOSITORY

A. The remote data repository shall exist at a site separate from the geothermal HVAC system.

B. The remote data repository shall store data in a time-series fashion in order to provide fast data access.

C. The remote data repository (database) shall provide the functionality of, at minimum:

1. Database of points from DDC system and calculated savings sampled at one-minute interval

2. Database storage capacity for all measured points for at least 15 years

3. Instantaneous access of any database point from single interface and single query language

4. Ability to trend any point for any duration of time with minute, hour, day, week, month and year rollup period

2.4 REMOTE WEB SERVER

A. The web server that serves the web user interface web site shall exist at a site separate from the geothermal HVAC system.

B. The web server that serves the web user interface web site shall allow:

1. Data to be viewed through website accessible on public internet. No virtual private network (VPN) shall be required.

2. Website access through public DNS, with standard top level domain.

a. Correct example: http://www.geothermal-mv.com/

b. Incorrect example: http://21.144.33.101/

3. Third party access to data through API.

4. At least 1000 concurrent viewers of website.

PART 3 - EXECUTION

3.1 DESIGN

A. The Geothermal M&V contractor shall design the measurement and verification system to allow accurate measurement of, at minimum:

1. Fluid temperature into and out of the geothermal resource

2. Fluid pressure into and out of the geothermal resource

3. Fluid flow rate into or out of the geothermal resource

4. Energy contributions from conventional (hybrid) HVAC equipment such as boilers and cooling towers.

5. Other sensors and equipment as specified by the Engineer of Record

B. The Geothermal M&V contractor shall coordinate with the DDC contractor to design a means of transmitting data from sensors and HVAC equipment to the Geothermal M&V system.

C. The Geothermal M&V contractor shall define the mathematical functions necessary for quantifying energy savings in real time, based on measurements from the facility.

1. The energy savings shall be computed based on the projected performance of the geothermal-based HVAC system compared to the projected performance of a conventional (baseline) system. This conventional system may be defined according to ASHRAE Standard 90.1-2010.

2. The mathematical functions shall be based on and substantially defined by the results of detailed computer simulations. The simulation environment shall be compliant with ASHRAE Standard 140.

3. The energy savings values shall be computed and stored to the database with an average frequency of once per minute.

D. The Geothermal M&V contractor shall define and configure mathematical functions for automatically providing users with an indication of the performance of the geothermal HVAC system. Such functions may be referred to as “alerts”, and shall trigger messages when events of interest occur within the system.

3.2 BUILDING NETWORK COMMUNICATIONS

A. The Geothermal M&V system shall read a set of data points from the DDC communication network. Data points will be transmitted (”offered up”) to the Geothermal M&V system via Tridium Niagara Framework, BACnet/IP protocol, or other mutually agreed upon protocol. Alternative protocols may be coordinated with the DDC system contractor.

B. The Geothermal M&V system contractor and DDC contractor shall coordinate to define data points communicated between the two systems.

1. The DDC contractor shall provide a list of all available network data points including descriptions of each data point.

2. The Geothermal M&V system contractor shall select a subset of data points to receive.

3. The Geothermal M&V system contractor shall transmit the selected data points to the remote data repository via the internet connection.

C. Software Integration Option: For cases where the DDC system includes a supervisory controller compatible with the Tridium Niagara Framework, the Geothermal M&V system shall include a software module or modules installed on the DDC contractor's supervisory controller. In such cases, no additional hardware Geothermal M&V microprocessor or web server hardware will be required on site.

D. Hardware Integration Option: For cases where the DDC system does not include a supervisory controller compatible with the Tridium Niagara Framework, the Geothermal M&V system shall include microprocessor and web server hardware according to the requirements of this section.

E. Stand Alone Option: Alternatively, and in cases where no DDC network exists, the Geothermal M&V contractor may provide, in addition to microprocessor and web server hardware, a communication network and/or an analog-to-digital converter and transmitter device for the purposes of directly measuring relevant sensors and equipment installed throughout the geothermal HVAC system. In such cases, the communication network shall include:

1. Non-proprietary communication protocol.

2. Defenses against unauthorized system use.

3.3 USER INTERFACE

A. The Geothermal M&V system shall include a web-based user interface that provides the functionality of, at minimum:

1. View geothermal savings and DDC point data with minute, hour, day, week, month and year rollup period.

2. Individual users can subscribe to alert messages via email, SMS, or web.

3. API to allow third-party access to system data in secure, structured format.

4. Administrator and user access levels.

5. Self-service user management.

6. Exporting user-configurable data histories

B. The web user interface shall display, at minimum:

1. A summary of the performance of the geothermal system

2. Sensor values and rates of heat exchange

3. Real-time energy savings values

4. Messages to system users

5. User-configurable data histories grouped by unit type, aligned by time range, with float over value display in metric or English units.

C. The web user interface shall include formats for, at minimum:

1. Personal computer web browsers (such as Google Chrome, Mozilla Firefox, Apple Safari, etc.)

2. Mobile device web browsers

3. Kiosk displays

D. The web user interface shall allow user-friendly navigation and shall convert values to familiar units of measure.

3.4 EXAMINATION

A. Verify appropriate installation of connections to the Geothermal M&V system.

B. Verify that IT connections and configurations have been completed by the owner or the owner’s representative.

C. Verify that systems are ready to receive work.

END OF SECTION 17810

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Provide a point-of-use type Aircraft Pre-Conditioned Air System (PCA) located at each passenger loading bridge comprised of fixed, packaged, air-cooled, direct expansion (DX) units with controls and related accessories for cooling, heating and ventilation of commercial aircraft while parked/attached to the Passenger Loading Bridge.
   1. The work/project will include all detailed design, manufacture, shipping/delivery, coordination of installation, project management, system testing and start-up, operator training and warranty support for the Pre-Conditioned Air system and all associated components as specified herein.
   2. All necessary controls, flexible air hose ducting and storage hose basket shall be included in the design and installation of the unit.

B. The work shall include the following general tasks to provide the Owner with a complete operational system in accordance with the requirements specified herein.
   1. System design, calculations and analysis, definition of interface requirements, preparation and submittal of system installation and equipment drawings for Owners approval, submittal of recommended spare parts list and testing/commissioning procedures.
   2. Preparation and submittal of drawings and other information necessary to acquire required permit, including associated fees, to perform the work. Provide insurance satisfactory to Owner/Airport and any other agency having jurisdiction.
   3. Manufacturing and procurement of all equipment and materials required for a complete operating system as defined herein.
   4. Factory testing of major functional equipment items as specified.
   5. Project management, scheduling, phasing of work and coordination of the project with the Owner and other contractors on-site.
   6. Installation of all equipment and materials, including loading, transport, off-loading at site, site preparation, storage and/or setting equipment in-place, mounting and affixing as required, interconnection/termination of power, controls and location/routing of drain lines.

7. In-process inspection and testing of installed equipment.
8. Complete acceptance testing of the installed system at all gates, along with documentation.
9. "As-built" drawings of the completed system.
10. Formal training for representatives as designated by the Owner.
11. Maintenance and Operation manuals.
12. Three (3) year warranty on all parts and equipment from the date of acceptance by Owner.

C. The system equipment, components, materials and installation shall be new, of the highest quality for the intended function and selected by the contractor to enable the system to operate in accordance with these specifications. These specifications provide minimum standards.

1.3 APPLICABLE CODES AND STANDARDS

A. All equipment, materials, construction and installation supplied or performed by the contractor shall be in accordance with the applicable requirements of the following codes and standards, of latest issue in effect on the date of the contract:
1. NEC – National Electrical Code.
2. NFPA – National Fire Protection Association.
3. NEMA – National Electrical Manufacturer's Association.
4. ANSI – American National Standards Institute.
5. ASME – American Society of Mechanical Engineers.
6. OSHA – U.S. Government, Occupational Safety and Health.
7. ARI – Air Conditioning and Refrigeration Institute.
    a. 410: Standard for Forced-Circulation Air Cooling & Heating Coils.
    b. 850: Commercial and Industrial Filter Equipment.
8. ASHRAE – American Society of Heating, Refrigeration and Air Conditioning Engineers.
    a. 15 Safety Code for Mechanical Refrigeration.
    b. 52 Method of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
9. AFBMA – Anti-Friction Bearing Manufacturer's Association.
10. UL – Underwriter's Laboratory.
11. All codes, regulations, and ordinances in effect by authorities having jurisdiction over the construction site.

1.4 ACTION SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for each principal component of each PCA unit, including certified test reports on required testing. Indicate rated capacities, sizes, performance and operating characteristics, features of control system, finishes, and similar information. Indicate any variations from specified requirements, and maximum dynamic and static loads imposed on PBB structure at points of support.

B. Shop Drawings: Submit equipment shop drawings detailing electrical and mechanical requirements for wiring and mounting, including control wiring. Include control logic diagrams. Submit installation shop drawings showing materials and methods of mounting and wiring, including electrical cable, conduit, junction boxes, fittings, clamps, grounding, brackets, hardware, NEMA classification or other industry rating as applicable.

C. Provide performance calculations demonstrating the capability of the high pressure blower, each evaporator stage and condenser(s) to meet the specified minimum performances. The calculations shall take into account losses in the air delivery hose, identifying the type and length of hose used with its overall insulation value. Provide for hoses of different manufacturers in these calculations so as not to limit the Owner from future use of any standard insulated hose available for aircraft air conditioning.

1.5 INFORMATIONAL SUBMITTALS

A. Recommended Spares List
   1. A recommend spares list shall be submitted covering all items of equipment and categorized accordingly, with current unit prices as well as recommended lot price. This list shall be submitted within 90 days after drawing approval.

1.6 CLOSEOUT SUBMITTALS

A. Manuals and Documents
   1. Operation, Maintenance, Recommended Spare Parts List, and Parts Manuals in accordance with ATA Specification 101, Revision shall be provided in a protective binder or cover at least 10 days prior to site acceptance. Manuals shall include, as a minimum:
      a. One section defining the overall operation of the system, start-up and shut-down and adjustment procedures, overall preventative maintenance charts, flow charts and a listing of major system components, with a guide to finding detailed information on these components in other sections.
      b. One section containing maintenance and operating details of the air handlers, with theory of operation, control diagrams, schematics, troubleshooting charts, complete alignment instructions, preventive maintenance details, parts lists, all in the general format and intent of ATA-101 as adapted for fixed facility equipment.
      c. One or more sections containing the standard vendor’s operating and maintenance manuals of all functional assemblies, including compressors, pumps, control valves, coils, etc., with catalog cuts of all devices.
      d. One section detailing system controls: operation, theory, control and ladder diagrams, program parameter adjustments, manual override techniques, parts lists.

e. Cross reference parts list, indicating contractor's part numbers as they appear in the manuals with corresponding original manufacturer's part numbers (if different than contractor).
f. Capacity information, curves, etc., same as provided for action submittals.
g. Include wiring and piping schematics and diagrams, troubleshooting and maintenance guide, service and repair guide, preventative maintenance schedule and procedures, theory of operation, recommended spare parts lists, special tools and factory contact procedures.
h. Included with the manuals shall be all software, software manuals, hardware manuals and licenses.

2. All schematics and diagram reference (number, name, etc.) of wires, relays, switches, pumps, motors, and etc. shall be the same as that shown on each component.
3. An electronic copy, CD-ROM, of the Operation, Maintenance, Recommended Spare Parts List, and Parts Manuals shall be provided.

B. Provide "As-Built" drawings of the finished and accepted system. As-built drawings shall be submitted within 30 days after system acceptance.

1.7 QUALITY ASSURANCE

A. Factory Testing:

1. Factory Test Reports shall be furnished for <u>each PCA unit</u> including test results instrument used, test procedures, and final conclusions. Each Test Report shall be dated and signed by authorized personnel and shall be neat, readily legible and self explanatory.
2. Test to be conducted shall, at a minimum, cover:
   a. Functionality of all electrical breakers.
   b. Current draw for all load conditions, total currently draw and for each component.
   c. Smoke detector activation.
   d. Damper Operation.
   e. Air Flow, Pressure and Temperature.
   f. Cycling of compressor.
   g. Unit operating controls.
   h. Safety devices.
3. Each PCA unit shall be given a "burn-in" test for at a minimum of 8 continuous hours.

B. Field Testing

1. Each PCA unit after installation shall be tested to verify compliance with contract specification. The Contractor shall provide airflow & pressure measuring equipment electrical meters and other test equipment required to perform test.
2. Field tests shall verify compliance with:
   a. Air Flow.
   b. Air Temperatures.

c. Pressure.
d. Smoke Detector Operation.
e. Control Operation.
f. Damper Operation.
g. Safety Device Operations.
h. Current Draw.
i. Others tests, as required.

C. Training

1. Training: During the checkout and test phases, owner personnel shall be invited to witness and to receive over-the-shoulder operation/adjustment training. Immediately prior to or within one week after system acceptance tests are conducted, the manufacturer/contractor shall conduct a minimum of 2-day training class for up to 8 personnel. The class shall consist of 50 percent classroom and 50 percent hands-on operation. This class shall be aimed at operating and maintenance personnel for basic operation, preventative maintenance, adjustment and initial fault response.
2. Contractor shall make available, under separate contract, optional additional training courses dealing with detailed maintenance of the controls and overall system troubleshooting and realignment, either at his factory, or at the job site.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle materials, components and equipment in manufacturer's protective packaging. Store materials, components, and equipment off of ground, under cover, and in a dry location.

1.9 WARRANTY

A. Equipment furnished under this specification shall be guaranteed against defective parts and workmanship under the terms of the manufacturer’s warranty for a period of not less than two (2) years, parts and labor, from the date of initial start-up and acceptance of the equipment by the Owner at the project site.

PART 2 - PRODUCTS

2.1 GENERAL

A. The design of the PCA equipment shall provide for a self-contained, air cooled, passenger boarding bridge-mounted air-conditioning unit. The system shall be capable of providing all heating, cooling, ventilation and control requirements in the design ambient conditions for the aircraft types as specified herein.

1. The Pre-Conditioned Air system shall be based on the installation of a fixed electrically operated DX unit to serve a single aircraft position (Gate). Only one (1) unit shall be allowed to be installed at each gate/bridge location.

2. The DX unit shall be mounted to the bridge in such a way as to allow air intake to the unit from the side/underside of the unit with a minimum of 18" clearance. The DX unit shall use a transition hose to transfer the air to the aircraft. All equipment shall be mounted to the bridge without restricting bridge operation, including but not limited to retraction, extension or rotation.
3. Each DX unit shall consist of multiple scroll-type refrigeration compressors and related air-cooled condensers, evaporators, piping (etc.) together with blower and inlet filter, outlet plenum section, electrical strip heaters, controls and safety devices, completely packaged in a single weatherproof unit.
4. For an apron-drive, telescoping bridge, the DX unit shall be mounted on the underside of the outer tunnel. All equipment shall be mounted to the bridge in such a way as to not restrict bridge operation, including but not limited to, retraction, extension and rotation beyond acceptable limits.
5. Each DX unit will be equipped with a digital controller using DDC technology to provide automatic cabin temperature control to within +/- 2 degrees of the pre-programmed internal unit's set point, via a cabin temperature sensor/probe.
6. Accessories shall be provided to deliver the Pre-Conditioned Air to the aircraft low-pressure air connection via a flexible air-hose and connector/coupling. A storage/hose basket mounted at the appropriate point/location at the base of each bridge shall be provided to store the flexible hose when not in use.
7. Each DX unit shall be provided with the required hardware, software, databases and any required site licenses to provide remote monitoring and control features if required.

2.2 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. JBT Aerotech - Jetway Systems, Inc.
   2. AXA Power
   3. Unitron LP.
   4. FCX Systems, Inc.
   5. Trilectron Industries..

2.3 PERFORMANCE REQUIREMENTS

A. Provide all heating, cooling, ventilation and control requirements in the design ambient conditions for the aircraft types as specified herein.

B. Aircraft Types:
   1. Gate 1: Bombardier CRJ-200 through B-767.
   2. Gates 2-4: Bombardier CRJ-200 through B-737 & A320.

C. Summer Design & Performance Conditions

1. The PCA unit shall be designed to maintain a 78 degree F +/-2 cabin temperature with a 50% RH in all aircraft for which it is designed to cool under the following conditions:
   a. Ambient Design Temperatures: ASHRAE 1% coincident day for Duluth International Airport, MN.
   b. Passenger Load: Full (100%) passenger and crew for the largest aircraft to be cooled. 255-275 BTU/Hr per person shall be used for the sensible heat passenger load calculations.
   c. Solar Load: Full (100%) bright sunshine.
   d. Aircraft Electrical Load: 75,000 BTU/Hour.
   e. Aircraft Doors: One door open.
   f. Air Flow Rate: 200 #/Min @ 22 inches of static pressure (single hose), measured at the discharge end of the 60 foot long hose – for narrow-bodied aircraft.
   g. Discharge Air Static Pressure: At the maximum airflow rate, discharge air static pressure shall be not less than 22 inches of water as measured at the end of all air delivery tubes, hoses, connectors, etc. when connected to an air flow test tube manufactured in accordance with ASHRAE Standard 51-1985, unless this pressure is more than the maximum allowable pressure permitted on any aircraft to be serviced, when measured at the end of all air delivery tubes, hoses, connectors etc., and when connected to and servicing the aircraft.
   h. Discharge Temperature: The lowest of the following:
      1) As required to removed the total heat load.
      2) 35 degree F as measured at the end of all air delivery tubes, hoses, connectors, etc.
   i. All temperatures, air flow rates, and static pressures must be simultaneously achievable.
2. The PCA system shall be capable of adjusting temperature and mass-flow to compensate for reduced passenger loads, lower ambient temperatures, or smaller aircraft.
3. The above cooling performance requirements shall be met using 100 percent outside make-up air to the DX unit.
4. Each PCA system shall be capable of performing a cabin temperature "pull down" of a heat soaked aircraft, from a temperature of 100°F to a temperature of 80°F or lower on a summer design day within a period of 45 minutes, with no occupants and all doors closed

D. Heating Design Conditions
1. The PCA unit shall be designed to maintain a 65 degree F +/-2 cabin temperature when heating all aircraft in its classification during the following design conditions:
   a. Ambient Dry Bulb Temperature: Winter -14 degree F.
   b. Passenger Load: No (0%) passenger and crew.
   c. Solar Load: No (0%) sunshine.
   d. Aircraft Electrical Load: No (0%) aircraft load.
   e. Air Flow Rate: 50% of the cooling air flow rate.
   f. Discharge Temperature: As necessary to supply the required heat load, but at no time should it exceed 140 degree F as measured at the end of all air delivery tubes, hoses, connectors etc., and when

connected to and servicing the aircraft. All temperatures, air flow rates, and static pressures denoted in this specification, must be simultaneously achievable.

2. Provide temperature and volume modulation capability to automatically and efficiently compensate for higher ambient, higher passenger loads or smaller aircraft.
3. The system shall be capable of maintaining an "overnight heating" mode on empty aircraft with all doors closed, with cabin temperature set for 60 degrees minimum in lieu of 68 degrees F, during ambient temperatures as much as 10 degrees F lower than the winter design condition. Each unit shall contain means for remotely resetting the preset cabin ambient control for this purpose.
4. Each PCA system shall be capable of pulling up the temperature of a cold-soaked aircraft cabin from 32 degrees F to 65 degrees F within a 45-minute period during design winter conditions with an empty aircraft of the largest size identified for the gate, with all doors closed.
5. A minimum electric heating rating of 30 kW for narrow body, and 45 kW for wide body shall be provided.

E. Ventilation: Each PCA system shall be designed to provide minimum air flow corresponding to 10 cfm per passenger in the cooling and ventilation modes and 5 cfm in the heating mode while maintaining the required cabin temperature. A combination of temperature and air flow modulation shall be used to support the heating or cooling requirements during moderate climate conditions.

2.4 MECHANICAL REQUIREMENTS

A. Refrigerants: R134A, or as approved by the Owner.

B. Condensation

1. The PCA unit shall incorporate an integral condensation pumping system to remove condensation. The condensate-collecting pan shall be integrated within the framework of the unit. "Catch Pans" shall not be acceptable.
2. Condensation shall be disposed of at a designated drain near the base of the bridge or on top of the terminal roof, or as required by local regulations. It shall not discharge onto the ramp as this causes a hazardous situation for ramp personnel and equipment.
3. Condensation pumps shall be self-priming, and adequately sized to carry the condensation to the designated area. The pump shall be programmed to operate only when required, i.e. not to run continuously.
4. The Condensate pump shall be installed to allow easy access for clean the inlet screen.

C. Airflow Control

1. Airflow control shall be via a motorized plate damper. Use of an Iris type damper is not acceptable. The damper and its actuator shall be mounted to the outlet side of the blower.
2. Airflow shall not be modulated during operation in order to control cabin temperature.

3. During starting of the PCA unit, the airflow control damper shall open gradually to avoid subjecting the system and the aircraft to the full impact of supply air at initial start-up.

D. Air Flow Ducting
   1. All ducting, plenum transitions, and other air flow components of the PCA unit are to be made from either aluminum or stainless steel and shall be insulated adequately to avoid condensation on the unit due to the cold supply air temperature.
   2. A rigid duct shall be provided immediately downstream of the unit to support the transition hose. A 45 degree elbow shall be provided at the end of the duct and oriented towards the hose basket. At the drive column scissors, a gap shall be provided in the rigid ducting to facilitate clearance for the scissor movement.

E. Air Filters
   1. Air filters shall be manufactured by a company regularly engaged in filter manufacturing.
   2. Filters should be washable, encased in a metal frame, and rated for the application for which they are being used. However, as a minimum, filter media should be at least 1 inch thick, constructed of galvanized woven and crimped steel screening. The metal frame shall be at least 20 gauge galvanized steel.
   3. The filter section shall be furnished with a differential pressure sensor measuring across all filters, to activate a “dirty filter” alarm, but the PCA unit shall not be shut down because of the alarm.

F. Hose Basket
   1. The PCA unit shall be equipped with an independent hose storage basket that is mounted directly to the aircraft side of the passenger boarding bridge and shall be either ground supported on rollers or bridge supported.
   2. The basket shall be located such that it and/or the air hoses, whether in use or being stored, do not interfere with or limit the full operating range of the passenger boarding bridge.
   3. The basket shall be fabricated from a minimum of 1-1/2 inch steel tubing.
   4. The basket shall be equipped with four swivel casters permitting movement with the bridge.
   5. The basket shall be adequately sized to accommodate all hoses and connectors when not in use.
   6. The basket shall be designed in such a manner that the bottom of the hose storage area is an open design allowing rain, snow, trash, etc. to pass through.
   7. The hose basket shall be designed in such a manner that ramp personnel shall not have to lift the air hose more than 1-1/2” from the ground.
   8. A detachable hose reel shall be provided to provide additional hose length to reach the DC9/MD80 aircraft inlet. The reel shall be equipped with lockable casters and connector for the primary hose aircraft adapter.

G. Air Hoses

1. Aircraft PCA hoses length shall be sized to service the aircraft mix specified. The hose shall be 14-inch diameter flat type, with a tapered elbow adapter and aircraft connector complying with MS-33562.
2. Hose is to be supplied in sections of no more than 25 feet, connected together with zippers, and the joint shall be covered with Velcro.
3. A transition hose (hose section between the unit and hose basket) shall be an insulated flexible hose with an internal wire support to prevent the hose from collapsing when there is no pressure. The transition section shall be sized to allow the for the outlet end of the transition hose to be at the top of the hose basket when the PLB is in the full up or highest position. . The transition hose assembly is to be connected to the discharge opening of the PCA unit and the aircraft connector with flatworm type metal clamps.
4. The PCA outlet duct shall be designed to mate with the metal clamp to prevent the hose from disengaging from the duct under the weight of the hose or during operation.

H. Blower
   1. The blower shall be of the centrifugal type and sized for the appropriate variable volume airflow requirements at 3600 rpm max. The unit size shall be selected so that the fan brake horsepower does not exceed the maximum required over the design operating range of the unit at the total static pressure. Horsepower shall be selected based on the contractor's choice of equipment that affects the external resistance of the system. The blower shall be statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and horsepower. The fan shaft shall be turned, ground and polished steel designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fan's class
   2. The blower-motor shall be high-efficiency type, ODP or TEFC, of standard frame size, with permanently lubricated bearings and adequately sized to prevent overloading throughout the entire spectrum of the blower performance curve.
      a. Motor shall be accessible for inspection or replacement from outside the unit via access panel, without requiring removal of any other components.
      b. Motor shall be UL-listed.
   3. The blower wheel and fan shaft assemblies shall be direct coupled to the motor. The maximum allowable vibration velocity shall not exceed .1 inch/second or .5 MIL displacement.
   4. Provide shaft bearings having a median life (AFBMA) of 200,000 hrs calculated in accordance with AFBMA 90 for ball bearings, or AFBMA 11 for roller bearings.

I. Condenser Fans and Motors
   1. Condenser fans shall be propeller type, direct-driven with permanently lubricated bearings.
   2. Condenser fan motors shall be of standard frame size, 3600 rpm maximum, ODP or TEFC, with permanently lubricated bearings

J. Evaporator and Condensor Coils

1. Coils shall be seamless copper tube with aluminum fins and removable from the unit. The evaporator coil section shall be completely insulated. The number of tubes and fin spacing shall be submitted.
2. Coils shall be proof tested to 400 psig and leak tested to 250 psig with air pressure under water, then cleaned, dehydrated and sealed with a holding charge of nitrogen.
3. No more than two compressor circuits shall be combined with a single evaporator coil.
4. Compressors shall be serviceable, hermetic “scroll type”. Each circuit shall have thermal expansion valves, filter drivers, sight glasses, minimum of two refrigeration circuits, fan cycling control for low ambient control to 45 degrees.

K. Size and Weight
1. The PCA unit shall be packaged to the minimum size possible, consistent with the performance and maintenance requirements of this specification.
2. Equipment weight shall be minimized by using lightweight materials where practical. The Contractor shall obtain from the bridge manufacturer, and shall forward to the Owner, written certification that the PCA unit will not hinder, restrict, or be detrimental in any way to the, maintenance access, performance and reliability of the passenger boarding bridge.

L. Noise and Vibration
1. Equipment shall not produce or induce objectionable vibrations into the bridge structure. Vibration levels induced by the unit and/or its components shall not be injurious to the unit or the bridge structure or be harmful or annoying to passengers and employees. The Manufacturer shall provide any and all necessary vibration insulation devices required to meet this requirement.
2. The maximum sound level for the PCA unit at maximum cooling/heating shall not exceed 85 dB at a distance of 15 feet from the unit (external) and 65 dB inside the bridge (internal).

M. Access Panels/Doors: Access doors and panels shall be provided for inspection and access to internal parts including condensers, compressors, expansion devices, valves, motors, blower, damper, heaters, condensate pump, and evaporators.
1. Removal panels shall be secured using 1/4-20 (minimum) machine screws. The use of TEK screws shall not be acceptable.
2. Full-length stainless steel piano hinges shall be provided on all access doors.
3. Quick release door latches shall be provided on all access doors.

2.5 ELECTRICAL REQUIREMENTS

A. General
1. All PCA units shall be constructed in accordance with standard electrical manufacturing processes, and shall be in accordance with all applicable Federal, State, and Local laws, codes and ordinances.
2. The PCA unit shall be U.L., CSA or E.T.L listed.
3. All wiring shall be permanently identified with an indelible process such as wire stamping or slip on type wire markers. Wrap around adhesive markers will not

be acceptable. Wire designations shall be selected in a logical sequence and to match unit's schematic diagrams. The Contractor shall provide samples for approval prior to manufacturing the PCA unit. Wire markers shall be installed within of all terminations and shall be readily visible.

4. Each PCA unit shall be wired to NEMA 3R Standards and provided with a means of external electrical disconnection. This device shall be lockable in the "OFF" position to facilitate maintenance.
5. The PCA shall be designed to operate from a power source of 480 volts, 3 phase, 60 Hz power. Methods, weights and locations of mounting and wiring schemes shall not in any way degrade the structural integrity of the bridge, provide safety hazards or affect any bridge warranties between the bridge manufacturer and the owner.
6. Motors shall be NEMA B, Class F Insulation, 1.15 Service Factor.
7. Compressor shall be Trane Scroll S units, or approved equal.
8. All wires within the control panel shall be run in "snap-track" wire troughs.
9. All electrical components shall be identified by engraved plastic placards affixed to the components' mounting plates.
10. All wires within the PCA units shall be run in conduit and terminated with appropriate fittings, i.e. j-boxes, motor inlet boxes, etc.

B. Controls

1. Controls shall be Direct Digital Controls (DDC) capable of automatically modulating supply air temperature to attain and maintain the set cabin temperature within +/- 2 degrees F at the sensing point.
   a. The controls system shall utilize a small temperature probe connected to the system by way of a small cable and jack in the bridge cab. The probe will be placed on board the aircraft in a designated location by the gate agent after the arrival of the flight and removed after APU start up and prior to departure. The automatic controller shall select the appropriate operating mode (cool, ventilate, heat) depending upon ambient temperature and/or the DX unit inlet air temperature and aircraft on-board conditions. The cabin temperature set point for the cooling mode and heating mode shall be re-settable via software control from within the DDC controller
   b. Each unit shall have the capability to be controlled in a manual control mode in case of failure of the automatic temperature sensing circuit. A manual override control to increase or decrease temperature shall be mounted in the bridge cab; this control shall become active whenever the cabin sensor probe or its cable is either missing or is detected as an open or short circuit.
   c. Control system shall include an Apron Management System Interface with Ethernet connection to allow integration with Building Management System.
2. The PCA unit shall utilize a push-button control station mounted on the bridge lift column (aircraft side of the bridge), accessible from ground level by ramp personnel at all times.
3. The push-button station shall operate on 24 volts.
4. The control station shall incorporate a "STOP" push-button, a "FAULT" light, aircraft type selector switch, and a "START" push-button that illuminates when the unit is running.

5. Selection of the mode of operation, i.e. COOL, VENT, or HEAT, shall be manual. A selector switch shall be furnished in the drive column control station.
6. A by-pass switch for the aircraft sensor probe. The switch shall be illuminated to indicate when the switch is in the by-pass mode.

C. Heat Strips
1. Heat strips shall be interlocked to prevent energizing in the absence of adequate air flow across the heat strips.
2. The heat strips shall be locked out of operation if ambient is greater than 65 degrees F.
3. The heat strips shall be deactivated if the plenum temperature exceeds 150 degree F. Upon plenum temperature returning to normal, the heat strips shall automatically re-activate. Thermal sensors shall incorporate a dead band to prevent unnecessary cycling of heat strips.

D. Smoke Detector
1. A smoke detector shall be located in the discharge side of the airflow plenum, which will shut off the PCA unit if smoke is detected.
2. The smoke detector shall be equipped with an auxiliary pair of Form C contacts, one Normally Open and one Normally Closed, to permit the connection to the smoke detector to the building fire alarm system if so desired.

E. Electromagnetic Interference
1. Units shall be designed so as not to affect aircraft radio/navigation equipment. It shall be applicable throughout the entire aircraft radio frequency range. Provisions shall be designed into the unit to protect it from voltage fluctuations, which might result from the operation of aircraft radio frequency equipment.

2.6 FINISHES AND MARKINGS

A. All metal parts shall be powder coat, applied per the paint manufacturer's recommendations.
1. Color: RAL 9002, Gray White.

B. All instruments, relays, circuit boards, controls, etc. and instructions shall be suitably identified with permanent non-fading metal and/or plastic placards or pictographs, either etched or silk-screened such that it is impervious to the effects of weather, oil, cleaning solvents, aircraft hydraulic fluids, fuel and other effects of normal operation for the life of the equipment without deterioration, fading or loosening.

C. An etched/or silk-screened electrical schematic fabricated from either metal or plastic material shall be mounted inside the main power panel door. Wiring schematic shall be mounted to the inside of the panel door using an appropriate adhesive. Screws shall not be used.

D. An etched/or silk-screened electrical schematic fabricated from either metal or plastic material shall be mounted inside the main power panel door. Wiring schematic shall be mounted to the inside of the panel door using an appropriate adhesive. Screws shall not be used.

2.7 WORKMANSHIP

A. The PCA unit, including all parts and accessories shall be fabricated and finished in a workmanlike manner. Particular attention shall be given to freedom from defects, burrs, sharp edges, quality of soldering, welding, brazing, painting, wiring, riveting, alignment of parts and tightness of assembly screws, bolts, etc.

2.8 DESIGN LIFE

A. The PCA unit shall be designed for a useful life of 20 years with usual and customary maintenance in accordance with manufacturer's recommendations.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Prior to commencing PCA installation, examine PBB's, as constructed; verify all critical dimensions and examine supporting structure and all other conditions under which work is to be installed. Notify Construction Manager in writing of any dimensional discrepancies or other conditions detrimental to the proper installation or performance of PCA work. Do not proceed with installation of PCA equipment until unsatisfactory conditions have been corrected in a manner acceptable to the installer.

3.2 INSTALLATION

A. General: Comply with manufacturer's instructions and recommendations for work required during installation.

B. The contractor shall be responsible for the complete system installation. All installation labor shall be performed by contractors licensed in the State and/or by the agency with jurisdiction over the jobsite and who meet all Insurance and bonding requirements. The installation includes all construction permits and other applicable approvals as required.

C. All wiring shall comply with airport building electrical standards including compliance with NEC.

3.3 FIELD QUALITY CONTROL

A. Acceptance Testing: Upon nominal completion of each PCA installation, and before permitting use of PCA equipment (either temporary or permanent), perform acceptance tests as required and recommended by Code and by governing regulations or agencies.

B. Advise Construction Manager, Owner, Architect, and inspection department of governing agencies in advance of dates and times tests are to be performed.

3.4 DEMONSTRATION

A. Instruct Owner's personnel in proper use, operations, and daily maintenance of PCA equipment. Review emergency provisions and procedures to be followed at time of failure in operation. Train Owner's personnel in normal procedures to be followed in checking for sources of operational failures or malfunctions. Confer with Owner on requirements for a complete maintenance program.

B. Make a final check of each PCA unit’s operation with Owner's personnel present and just prior to date of Substantial Completion. Determine that control systems and operating devices are functioning properly.

END OF SECTION 15780

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes furnishing of solid-state, PWM, VFCs for speed control of three-phase, squirrel-cage induction motors.

B. Related Sections include the following:

1. Division 16 Section “Variable Frequency Controllers (Installation of)” for installation of VFC’s.

2. Division 15 Section “Enclosed Controllers” for control wiring.

1.3 DEFINITIONS

A. BMS: Building management system.

B. IGBT: Integrated gate bipolar transistor.

C. LAN: Local area network.

D. PID: Control action, proportional plus integral plus derivative.

E. PWM: Pulse-width modulated.

F. VFC: Variable frequency controller.

1.4 SUBMITTALS

A. Product Data: For each type of VFC. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

B. Shop Drawings: For each VFC.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

(a) Each installed unit's type and details.

(b) Nameplate legends.

(c) Short-circuit current rating of integrated unit.

(d) UL listing for series rating of overcurrent protective devices in combination controllers.

2. Wiring Diagrams: Power, signal, and control wiring for VFCs, including connections for external wiring. Provide schematic wiring diagram for each type of VFC.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For VFCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section “Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for VFCs and all installed components.

E. Harmonics: Submit calculations to demonstrate that the total harmonics produced by all of the VFC’s connected to the system at the electrical service point shall be no greater than the allowable harmonics as follows:

1. The total harmonics produced by all of the VFC’s connected to the system, including VFC's provided integral with HVAC equipment, at the Point of Common Coupling (PCC) shall be no greater than the allowable harmonics for “Special”,“General”,“Dedicated”] systems as specified by IEEE Standard 519 tables 10.2 and 10.3, based on the installed source KVA. The PCC shall be the primary side of the electrical service transformer(s) for calculating current distortion, and the PCC shall be the secondary side of the electrical service transformer(s) for calculating voltage distortion. Where the installed source KVA is not indicated on the Electrical drawings, calculations shall be based on 60 percent of the KVA of the service switches[, not including the fire pump.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain VFCs of a single type through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70, as amended by state and local codes.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:

1. Ambient Temperature: 0 to 40 deg C.
2. Humidity: Less than 90 percent (noncondensing).
3. Altitude: Not exceeding 3300 feet (1000 m).

1.7 COORDINATION

A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate features of VFCs, installed units, and accessory devices with pilot devices and control circuits to which they connect.

C. Coordinate features, accessories, and functions of each VFC and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: The following vendors will be reviewed for approval providing they meet all of the performance requirements of the specifications.

1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
2. Eaton Corporation; Cutler-Hammer Products.
3. General Electric Company; GE Industrial Systems.
4. Siemens Energy and Automation; Industrial Products Division.
5. Square D.
6. Unico, Inc.
7. Yaskawa Electric America

2.2 VARIABLE FREQUENCY CONTROLLERS

A. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.

1. Provide unit suitable for operation of standard efficiency and premium efficiency motors as defined by NEMA MG 1.
2. VFC's for operation of motors 30 horsepower and larger are equipped with 12 pulse or greater inverter sections.

3. VFC's for operation of motors less than 30 horsepower are equipped with 6 pulse or greater inverter sections.

B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

C. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.

D. Unit Operating Requirements:
1. Input ac voltage tolerance of 208 V, plus or minus 5 percent or 380 to 500 V, plus or minus 10 percent. As indicated on the equipment schedule.

2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.

3. Minimum Efficiency: 96 percent at 60 Hz, full load.

4. Minimum Displacement Primary-Side Power Factor: 96 percent.

5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.

6. Starting Torque: 100 percent of rated torque or as indicated.

7. Speed Regulation: Plus or minus 1 percent.

E. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.

F. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.

2. Maximum Speed: 80 to 100 percent of maximum rpm.

3. Acceleration: 2 to a minimum of 22 seconds.

4. Deceleration: 2 to a minimum of 22 seconds.

5. Current Limit: 50 to a minimum of 110 percent of maximum rating.

G. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors.

2. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.

3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class 20 performance.

4. Skip frequencies: Drive is arranged to skip a minimum of 3 field adjustable

frequencies where the controller-motor-load combination operates at a natural resonant frequency of the combination. Each is adjustable with a selectable bandwidth.

5. Instantaneous line-to-line and line-to-ground overcurrent trips.

6. Loss-of-phase protection.

7. Reverse-phase protection.

8. Short-circuit protection.

9. Motor over-temperature fault.

10. Control circuit (120 volts) for interlocking with dry contacts in load side motor disconnect to disable start-up attempts with system open.

11. Snubber networks to project against malfunction due to system voltage transients.

H. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.

I. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Attempts unlimited restarts after controller fault or on return of power after an interruption where serving motors used for smoke control systems, with no manual intervention required. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

J. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

K. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

L. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

M. Decelerating Energy Absorption: Means of absorbing energy released by decelerating motor (and its driven load) without damage to VFC, motor, or load.

N. Input Line Conditioning: Line reactors (5 percent) on 6 pulse VFCs to reduce harmonics produced by the VFC's.

1. Protect each VFC against injurious overheating at its full load rating.

2. Line reactors / passive harmonic filters are incorporated as an integral part of the controller equipment in a single cabinet. Where factory-mounting of VFC's are provided on packaged equipment, it is acceptable to mount remotely. Include all required field wiring.

3. The harmonic mitigation equipment shall treat all of the characteristic low frequency harmonics generated by a 3-phase, diode bridge rectifier load (5th, 7th, 11th, 13th, etc.).

4. The characteristic harmonics shall be suppressed without the need for individual tuning or the requirement to phase shift against other harmonic sources.

5. Harmonic mitigation shall be by passive inductor/capacitor network. Active electronic components shall not be used.

6. Power factor shall be .98 lagging to .95 leading in operating range from full to half load.

7. To ensure compatibility with engine generators, the harmonic mitigation equipment must never introduce a capacitive reactive power (KVAR), which is greater than 20% of its kVA rating.

8. The harmonic mitigation equipment shall not resonate with system impedances or attract harmonic currents from other harmonic sources.

9. The harmonic mitigation equipment in combination with the Variable Frequency Drive shall meet all requirements as outlined in the 1992 edition of IEEE std 519 for individual and total harmonic voltage and current distortion. The Point of Common Coupling (PCC) for all voltage and current harmonic calculations and measurements shall be the input terminals to the harmonic mitigation equipment.

10. Total Harmonic Voltage Distortion (THVD) shall meet the requirements of Table 10.2 of IEEE std 519 by not exceeding 5% and by limiting the individual harmonic voltage distortion to less than 3%. These limits shall apply while operating on either utility supply or generator supply when applicable. The harmonic mitigation equipment vendor shall not be responsible for pre-existing voltage distortion caused by other harmonic sources.

11. Total Demand Distortion (TDD) of the current at the input terminals of the harmonic mitigation equipment shall not exceed the limits as defined in Table 10.3 of IEEE std 519. For Isc/IL ratio < 20, TDD must be less than 5%. For all other Isc/IL ratios, the TDD must not exceed 8% even when Table 10.3 allows for more relaxed limits. For single-phase applications, the TDD must not exceed 12%.

12. The full load efficiency of the harmonic mitigation equipment / VFD combination shall be greater than 96%. The harmonic mitigation equipment itself shall have efficiency no less than 99%.

13. Maximum of one drive shall be connected a single filter.

O. DC Bus choke: For harmonic distortion reduction.

P. VFC Output Filtering: The variable frequency controllers are suitable for use with standard NEMA Design B motors having a service factor of 1.15 without producing any injurious “ringing” over-voltages as the motor terminals. Incorporate L-C filters (and/or other items) in the output of the drive as required to prevent such over voltages based on the circuit length from VFC to motor. Provide written certification of the suitability of the VFC for use with “standard motors.”

Q. Status Lights: Door-mounted LED indicators shall indicate the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

R. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

S. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (VDC).
9. Set-point frequency (Hz).
10. Motor output voltage (V).

T. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V and 0/4-20 mA) and 6 programmable digital inputs.

2. Pneumatic Input Signal Interface: 3 to 15 psig (20 to 104 kPa).

3. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
   (a) 0 to 10-V dc.

   (b) 0-20 or 4-20 mA.

   (c) Potentiometer using up/down digital inputs.

   (d) Fixed frequencies using digital inputs.

   (e) RS485.

   (f) Keypad display for local hand operation.

4. Output Signal Interface:
   (a) A minimum of 2 analog output signals (0/4-20 mA), which can be programmed to any of the following:

      (1) Output frequency (Hz).

      (2) Output current (load).

      (3) DC-link voltage (VDC).

      (4) Motor torque (percent).

      (5) Motor speed (rpm).

      (6) Set-point frequency (Hz).

5. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of each of the following:
   (a) Motor running.

   (b) Set-point speed reached.

   (c) Fault and warning indication (overtemperature or overcurrent).

   (d) PID high- or low-speed limits reached.

6. Damper Control Interface: Closes a dry contact upon a start command to open associated dampers before the motor is allowed to operate in drive or bypass mode. Input to accept damper limit switch contact closure to allow the motor to operate.

7. Safety Control Interface: Input to accept safety device dry contact closure to stop motor operation in drive and bypass mode.

8. Over-ride Control Interface: Input to accept control system dry contact closure to start motor operation in drive mode at variable speed and in bypass mode.

U. Communications: Provide an RS485 interface allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control, and all output signals and alarms of VFC to be monitored by BMS. Provide capability for VFC to retain settings programmed via BMS control within the nonvolatile memory.

V. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch sets mode, and indicator lights give indication of mode selected. Unit shall be capable of stable operation (starting, stopping, and running), with motor completely disconnected from controller (no load).

W. Bypass Controller: NEMA ICS 2, full-voltage, nonreversing enclosed controller with across-the-line starting capability in manual-bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode. Bypass controller for motors 75 HP and larger (10 HP and larger where supplied from an emergency generator) are provided with solid-state reduced voltage controller (soft-start) in series with the bypass contactor, as specified in Division 15 Section “Enclosed Controllers”.

X. Integral Disconnecting Means: NEMA KS 1, nonfusible switch with lockable handle.

Y. Isolating Switch: Non-load-break switch arranged to isolate VFC and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

2.3 ENCLOSURES

A. NEMA 250, Type 1 enclosure unless otherwise indicated.

B. NEMA 250, Type 4 enclosure where located outdoors. Heater and air-cooled cooling unit to maintain temperature within housing as required for proper operation for outdoor temperatures within the range of the ASHRAE 99.6 percent winter design temperature and ASHRAE 0.4 percent summer design temperature for the area, plus solar load. Single point electrical connection for controller and enclosure.

2.4 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

C. Control Relays: Auxiliary and adjustable time-delay relays.

D. Standard Displays:

1. Output frequency (Hz).

2. Set-point frequency (Hz).

3. Motor current (amperes).

4. DC-link voltage (VDC).

5. Motor torque (percent).

6. Motor speed (rpm).

7. Motor output voltage (V).

2.5 FACTORY FINISHES

A. Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested VFCs before shipping.

PART 3 - EXECUTION

3.1 APPLICATION

A. Select features of each VFC to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, drive and load.

B. Select rating of controllers to suit motor controlled.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:

1. Inspect variable frequency controllers, wiring, components, connections, and equipment installation. Test and adjust variable frequency controllers, components, and equipment in accordance with NETA ATS, Sections 7.5, 7.6, and 7.16. Certify compliance with test parameter.

2. Operate variable frequency controller throughout its full frequency range and program to skip frequencies where the controller-motor-load combination operates at a natural resonant frequency of the combination.

3. Complete installation and startup checks according to manufacturer's written instructions.

4. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

B. Test Reports: Prepare a written report to record the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

4. Report results in writing.

3.3 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain variable frequency controllers. Refer to Division 1 Section “Demonstration and Training."

3.4 INSTALLATION

A. VFC’s to be installed as part of Division 16 work.

3.5 CONTROL WIRING

A. Provide control wiring as specified in Division 15 Section “Enclosed Controllers”.

END OF SECTION 15942

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1. Section 15010 - Basic Mechanical Requirements.
2. This section is a part of each Division 15000 Section (Mechanical).
3. Specified elsewhere:

a. Variable Speed Control
b. Motors
c. HVAC Pumps
d. Chillers
e. Cooling Tower
f. Boilers
g. Terminal Air Distribution
h. Fans
i. Air Handling Units
j. Testing, Adjusting and Balancing
k. Basic Elec. Materials Methods
l. Electrical Wiring

B. Technical Proposals

1. Technical proposals shall be prepared in accordance with these specifications. Four (4) copies of the proposal shall be submitted with the bid. Proposals that are unbound, loose, loose in a file folder, stapled, stapled in a manila file folder, etc., will not be acceptable. The technical proposal shall include the following data/information as a minimum. The order of listing here is not intended to indicate, nor should it be construed to indicate, the relative importance of the data/information:

a. Information on organizational capability to handle this project (management, personnel, manufacturing, single source responsibility, etc.). Provide an organizational chart of the local factory branch office indicating the project team and each person's role in the project. Provide a resume for each project team member and all management personnel.

b. A comprehensive bar chart project schedule indicating submission of shop drawings, equipment delivery, installation, start-up commissioning, training, milestones, and all critical path tasks.

c. A project specific on-site and off-site training program which demonstrates specification compliance.

d. BMS Configuration as Proposed:

1) Modularity.

2) Provisions against obsolescence due to technological advancement.

3) Detailed description of all operating, command, application and energy management software provided for this project.

4) Provide a riser drawing of the system architecture. The drawing shall indicate the model number, location and service of each primary control panel, secondary control panel, PC workstation and all other network hardware.

5) A complete description of the chiller plant integration and/or optimization package, if applicable.

6) A complete description of all interface and/or integration packages.

7) Provide a complete submittal of all hardware, software, sensors and end devices (valves, damper operators, airflow stations, etc.).

8) Description of manual override operation and BMS monitoring of manual override operation and BMS monitoring of manual override for each type control point in system.

9) A list of references (include Owner contact name and phone number) for five (5) projects completed by the local branch office within the last five years of similar size, schedule and complexity.

10) A line by line BMS specifications concordance summary. The summary shall be in table form and indicate each article and paragraph by number and whether the proposed BMS contractor “Does Comply” or “Does Not Comply” with the paragraph. If the item does not comply, the bidder shall provide a written explanation.

11) A signed certificate stating the Contractor “has read the performance and functional requirements, understands them, and the technical proposal will comply with all parts of the specification” or a signed line by line specification concordance statement. Certificate or statement shall be signed by a person having the authority to guarantee the statement.

1.2 SUMMARY

A. General Work Description

1. Building Management System (BMS) controls contractor shall provide:

   a. A fully integrated building management system (BMS), UL-listed, incorporating direct digital control (DDC) for energy management, equipment monitoring, and HVAC control.

   b. Electronic sensors.

   c. Actuators of terminal equipment valves and dampers shall be electric. All sensors shall be electric/electronic.

   d. Actuators for valves and dampers located within the MER's shall be electric.

   e. All line voltage and low voltage wiring, conduit, panels, and accessories for a complete operational system. All final electrical connections to each stand-alone DDC Controller.

   f. BMS Contractor shall be responsible for all electrical work associated with the BMS and as shown in the contract documents. The BMS contractor shall be responsible for all electrical work associated with any BMS interface to any other systems including but not limited to HVAC and plumbing systems.

   g. The BMS contractor shall furnish all wells for water monitoring devices, flow switches, and alarms.

   h. A complete operational system including all work required for a completely operational system as defined in the entire set of drawings and specifications, including but not limited to associated specifications for mechanical and electrical work, all contract drawings, BMS Point List, and remote function schedule.

   i. The BMS system as a whole shall have the capability to be easily expanded through the addition of point modules and/or controllers. No equipment shall be installed which cannot, as installed, accommodate an upgrade the entire system by at least 25%. A 25% system upgrade shall include 25% more points (of each type) either via point modules or controllers and 25% more memory capacity for future connections.

   j. Provide appropriate labor jurisdiction to mount, wire and pipe airflow measuring stations in the field. Provide manpower as required to meet project schedule.

1.3 DEFINITIONS

A. AI - Analog Input

B. ANSI - American National Standards Institute

C. AO - Analog Output

D. ASCII - American Standard Code for Information Interchange

E. AWG - American Wire Gauge

F. BMS - Building Management System

G. CPU - Central Processing Unit

H. CRT - Cathode Ray Tube

I. DAC - Digital to Analog Converter

J. DDC - Direct Digital Control

K. DI - Digital Input

L. DO - Digital Output

M. EEPROM - Electronically Erasable Programmable Read Only Memory

N. EMI - Electromagnetic Interference

O. FAS - Fire Alarm Detection and Annunciation System

P. HOA - Hand-Off-Auto

Q. IEEE - Institute of Electrical and Electronics Engineers

R. I/O - Input/Output

S. LAN - Local Area Network

T. LCD - Liquid Crystal Display

U. LED - Light Emitting Diode

V. MCC - Motor Control Center

W. NC - Normally Closed

X. NO - Normally Open

Y. OWS - Operator Workstation

Z. OAT - Outdoor Air Temperature

AA. PC - Personal Computer

BB. RAM - Random Access Memory

CC. RFI - Radio Frequency Interference

DD. RH - Relative Humidity

EE. ROM - Read Only Memory

FF. RTD - Resistance Temperature Detector

GG. TCP/IP - Transmission Control Protocol/Internet Protocol

HH. UPS - Uninterruptible Power Supply

II. VAC - Volts, Alternating Current

JJ. VAV - Variable Air Volume

KK. VDC - Volts, Direct Current

LL. WAN - Wide Area Network

1.4 SYSTEM DESCRIPTION

A. General Product Description

1. The building management system (BMS) shall integrate multiple building functions including equipment supervision and control, alarm management, energy management and historical data collection.

2. The building management system shall consist of the following:

a. Independent, Primary Control Panels (PCPs) for control of each air handler, each AC unit, each chiller, each pumping system, and each hot and chilled water system (including pump control). The intent of this specification is that the loss of any one Primary Control Panel shall affect only the points connected to that specific PCP and shall not affect the operation of any other HVAC system. Motors in motor control centers shall be controlled only from Primary Control Panel associated with the respective HVAC system. It shall not be acceptable to control all motors in a MCC from a Primary Control Panel(s) dedicated to the MCC.

b. Stand-alone, Secondary Control Panels for terminal equipment only (CAV, FP VAV, VAV units, EDH, Fancoil, etc.).

c. Portable operator's terminals (POTs) to be connected and communicating simultaneously with the entire Primary Network from any Primary Control Panel. The portable operators terminals shall be able to simultaneously monitor, adjust, trend, edit, modify, add, delete, backup the entire B.M.S system (including Secondary Control Panels, Primary Control Panels, etc.) point database and all programs.

d. Personal computer operator workstation(s) and associated peripherals. The personal computer operator workstation shall reside on the same network as the primary control panels.

3. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, Primary Control Panels, Secondary Control Panels and operator devices.

4. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each Primary Control Panel shall operate independently by performing its own specified control, alarm management, operator I/O and data collection. The failure of any single component or network connection (including a wire break) shall affect only the system controlled by the specific PCP and shall not interrupt the operation of any other SCP, PCP, etc. In addition, the failure shall not affect or interrupt the execution of any control strategy, reporting, alarming and trending function, or any function at any operator interface device.

5. Primary Control Panels shall be able to access any data from, or send control commands and alarm reports directly to, any other Primary Control Panels or combination of Primary Control Panels on the network without dependence upon a central or intermediate processing device. Primary Control Panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device.

6. Operators shall be able to assign password access and control priorities to each HVAC system or interfaced system individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control only the system that the operator is authorized for. All other systems shall not be displayed at the PC workstation or portable terminal. Passwords and priority levels for every system shall be fully programmable and adjustable. This provision shall be applicable to all systems accessed either locally or remotely.

1.5 SEQUENCE OF OPERATION

A. Refer to Section 15951 for Sequence of Operations.

1.6 SUBMITTALS

A. General

1. Indicate at the beginning of each submittal, all substitutions and deviations from requirements of Contract Documents.

B. Product Data

1. Technical bulletins and catalog data for all equipment and system components. Clearly identify, by use of symbol or tag number, the service of each item. All irrelevant information shall be marked out leaving only pertinent data.

C. Shop Drawings

1. Shop drawing submittals shall comply with Division 1 and other specified requirements and shall include sufficient data to indicate complete compliance with Contract Documents. Submission shall be in the form of drawings, brochures, bulletins, catalog data and/or narrative descriptions.

2. Submission shall include, but not be limited to:

a. Symbol and abbreviation lists.

b. System block diagram showing quantity and location of personal operator workstation(s), Primary Control Panels, Secondary Control Panels, and locations of power feeds to BMS and other major system components. Show quantity and location of compressed air plant if compressed air plant is specified.

c. Control diagrams for all systems controlled. Controls shall be shown on system flow diagrams.

d. Power wiring diagrams and electrical requirements.

e. Interfaces (software and hardware) with other equipment provided in other sections of specifications including but not limited to chiller control system.

f. Narrative description of operation for each system, enumerating and describing the function of each component. Include alarm and emergency sequences, and equipment interlocks.

g. Description of manual override operation for every input and output point.

h. Complete input/output point schedule. Identify point function, type and location.

i. Spare capacity provisions.

j. Detailed bill of materials.

k. Valve and damper schedule: Provide identification numbers, location, system, dimensions and performance data. Include damper leakage rates.

l. Device mounting details. Include as a minimum:

1) Sensing elements in ducts and casings.

2) Sensing elements in piping.

m. Ladder wiring diagrams.

n. Other information as requested herein.

o. Complete full size drawings, 11" x 17" minimum.

D. Programming

1. Point identification code.

2. System advisory messages, printouts, logging formats.

3. Drawings of system graphics showing monitored points. (Include only if graphics are specified elsewhere in this specification).

4. Software flow-charts for applications and DDC programs.

5. Person machine interface program, including commands, alarm annunciation, logs and programming capabilities.

6. Description of system operation under failure conditions.

E. Samples

1. All wall, pipe and duct sensors.

2. All other devices mounted on finished surfaces.

3. Valve, damper, panel and sensor tags.

F. Quality Control Submittals

1. UL, FM, CSA listing compliance certificates.

2. Final calibration, commissioning and testing reports.

G. Time Requirements

1. Within thirty (30) days of award of contract manufacturer shall provide schedule of all submittals employing format as provided hereinafter and enumerating all drawings, samples and miscellaneous submittals by name, quantity, etc.

1.7 QUALITY ASSURANCE

A. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

B. All portions of the system must be of the same manufacturer and must be designed, furnished, installed, commissioned and serviced by manufacturer employed, factory trained employees. Systems proposed by distributors, manufacturer's representatives, and/or independent contractors shall not be considered and are not acceptable.

C. Single source responsibility of supplier shall be the complete installation and proper operation of the BMS and control system and shall include debugging and proper calibration of each component in the entire system.

D. Supplier shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.

E. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

F. BMS shall comply with UL 916 PAZX and 864 UDTZ and be so listed at the time of bid.

G. System devices shall have UL 864 (UUKL smoke control) and shall be so certified at time of bid.

H. All system components shall be fault-tolerant. System shall include:

1. Satisfactory operation without damage at 110% and 85% of rated voltage and at plus 3 Hertz variation in line frequency.

2. Static, transient and short-circuit protection on all inputs and outputs.

3. Protection for communication lines against incorrect wiring, static transients and induced magnetic interference.

4. Network-connected devices to be AC coupled or equivalent so that any single device failure will not disrupt or halt network communication.

5. All real time clocks and data file RAM to be battery-backed for a minimum 72 hours and include local and remote system low battery indication.

I. The Bidder shall be regularly engaged in the manufacturing, installation and maintenance of BMS systems and shall meet the following qualifications.

1. A minimum of ten (10) years of demonstrated technical expertise and experience in the manufacture, installation and maintenance of BMS systems similar in size and complexity to this project.

2. A maintained service organization consisting of at least three (3) competent servicemen, within 50 miles of the project site, for a period of not less than ten years.

3. The Bidder shall not be considered qualified to bid this project unless they can provide a list of 10 projects, similar in size and scope to this project, completed within the last five years.

J. The system manufacturer/installer shall provide a full-time, experienced project manager for this work from beginning of control installation until final completion. The project manager responsible for direct supervision of the design, installation, start-up and commissioning of the BMS as well as attending of project meetings whenever directed by the owner, construction manager, and/or mechanical contractor. It shall not be acceptable to change the project manager after the project has begun and before final completion.

K. Comply with all current governing codes, ordinances, and regulations including UL, NFPA, the local Building Code, NEC, etc.

L. The manufacturer of the building management system shall provide documentation supporting compliance with ISO-9002 (model for Quality Assurance in Production, Installation and Servicing). The intent of this specification requirement is to ensure that the products and services that the manufacturer and installer provide are delivered through a Quality System and Framework that will assure consistent quality throughout the project.

M. The system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability for any existing control system component including but not limited to Primary Control Panels, Secondary Control Panels, personal operator workstations, and portable operator's terminals, to be connected and directly communicate with any new BMS system equipment without bridges, routers or protocol converters.

N. In order to ensure the availability of rapid response, the BMS Contractor shall have a local facility or authorized service agent within a 50-mile radius of the job site. On-site emergency service shall be available on a 24-hour, 7-day-a-week basis.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

1.9 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 13 Section 16721 "Fire Alarm" to achieve compatibility with equipment that interfaces with that system.

C. Coordinate supply of conditioned electrical circuits for control units and operator workstation.

D. Coordinate equipment with Division 16 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.

E. Coordinate equipment with Division 16 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

F. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

1.10 EXTRA MATERIALS

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

B. Replacement Materials: Provide one replacement component for each unique control device including as a minimum:

1. Panels:

   a. DDC panel board components.

   b. Relays.

   c. Power supplies and transformers.

2. Field input devices:

   a. Space, air and water temperature sensors.

   b. Space and air humidity sensors.

   c. Air and water differential pressure transmitters.

   d. Static pressure transmitter.

   e. Air and water differential switch.

   f. Freezestat

   g. Current switches.

3. Field output devices:
   a. Actuators for dampers and valves excluding butterfly valves.
   b. Electric-pneumatic transducers or switches.

C. Maintenance Materials: Any unique or special tools that are required for proper operation, maintenance and repair as outlined in the system operation, maintenance and repair manuals shall be provided.

D. Provide a complete list of replacement and maintenance materials in the technical proposal.

1.11 RECORD DOCUMENTS

A. Owner’s Manual General

1. Submit two (2) draft copies of owner's manuals for review. After review by authorized representative, the contractor shall incorporate review comments and shall submit four (4) interim final copies. Upon completion of project, acceptance of project by the owner, submit six (6) copies of final "as built" manuals and one (1) reproducible copy (3-mil sepia Mylar).

2. Update manuals with modifications made to system during guarantee period. Provide replacement pages or supplements in quantity stated above for "as built" manuals.

3. Assemble owner's manuals into multi-volume sets.

4. Protect each volume with a heavy-duty vinyl plastic binder. Volumes to have plastic printed dividers between major sections and have oversized binders to accommodate up to _ inch thick set of additional information.

5. Each binder to be silk screened with project name and volume title on front cover and binder.

6. On the first page of each manual identify with project name, title, owner's name, engineer's name, contractor's name, address and service phone number, and person who prepared manual.

B. Provide an operating manual to serve as training and reference manual for all aspects of day-to-day operation of the system. Include as a minimum:

1. Control flow diagrams for all building systems.

2. Sequence of operation for automatic and manual operating modes for all building systems. The sequences shall cross-reference the system point names.

3. Description of manual override operation of all control points in system.

4. BMS system manufacturer's complete operating manuals.

C. Provide a maintenance manual to serve as training and reference manual for all aspects of day-to-day maintenance and major system repairs. Include as a minimum:

1. Complete as-built installation drawings for each building system.

2. Overall system electrical power supply scheme indicating source of electrical power for each system component. Indicate all battery backup provisions.

3. Overall system shielding and grounding scheme indicating all major components and ground paths.

4. Drawings showing installation details and locations of equipment.

5. Charts showing normal operating conditions at significant points such as electrical test points.

6. Routine preventive maintenance procedures, corrective diagnostics troubleshooting procedures, and calibration procedures.

7. Parts lists with manufacturer's catalog numbers and ordering information.

8. Lists of ordinary and special tools, operating materials supplies and test equipment recommended for operation and servicing.

9. Manufacturer's operating, set up, maintenance and catalog literature for each piece of equipment.

10. Maintenance and repair instructions.

11. Recommended spare parts.

12. Field test reports.

D. Provide a programming manual to serve as training and reference manual for all aspects of system programming. Include as a minimum include the following:

1. Complete programming manuals and reference guides.

2. Details of any special software packages and compilers supplied with system.

3. Information required for independent programming of system.

4. Point schedule including all points, real and pseudo.

5. Project specific software troubleshooting procedures.

E. Maintenance Data and Operating Instructions:

1. Maintenance and operating manuals in accordance with Section 01010, General Requirements.

a. Prepare data in the form of an instructional manual.
b. Contents: Prepare a Table of Contents for each volume, with each Product or system description identified, in three parts as follows:

1) Part 1: Directory, listing names, addresses, and telephone numbers of Architect/Engineer, Contractor, Subcontractors, and major equipment suppliers.

2) Part 2: Operation and maintenance instructions arranged by system and subdivided by specification section. For each category, identify names, addresses, and telephone numbers of Subcontractors and suppliers. Identify the following:

a) Significant design criteria.

b) List of equipment.

c) Parts list for each component.

d) Operating instructions.

e) Maintenance instructions for equipment and systems.

3) Part 3: Project documents and certificates, including the following:
a) Shop drawings and product data.
b) Certificates.
c) Photocopies of warranties.
d) Photocopies of bonds.

2. Contents, Each Volume

a. Table of Contents: Provide title of project; names, addresses, and telephone numbers of Architect/Engineer, Sub-consultants and contractor with name of responsible parties; schedule of products and systems, indexed to content of the volume.

b. For each Product or System: List names, addresses and telephone numbers of Subcontractors and suppliers, including local source of supplies and replacement parts.

c. Product Data: Mark each sheet to clearly identify specific products and component parts, and data applicable to installation. Delete inapplicable information.

d. Drawings: Supplement product data to illustrate relations of components parts of equipment and systems, to show control, flow and wiring diagrams. Do not use Project Record Documents as maintenance drawings.

e. Narrative Text: As required to supplement product data. Provide logical sequence of instructions for each procedure, incorporating manufacturer's instructions.

f. Warranties.

g. Bonds.

3. Manual for Equipment and Systems

   a. Each item of equipment and each system: Include description of unit or system and component parts. Identify function, normal operating characteristics, and limiting conditions. Include performance curves, with engineering data and tests, and complete nomenclature and model number of replaceable parts.

   b. Panelboard Circuit Directories: provide electrical service characteristics, controls, and communications.

   c. Include color-coded wiring diagrams as installed.

   d. Operating Procedures: Include start-up, break-in and routine normal operating instructions and sequences. Include regulation, control stopping, shutdown and emergency instructions. Include summer, winter, and any special operating instructions.

   e. Maintenance Requirements: Include routine procedures and guide for preventative maintenance and trouble shooting; disassembly repair, and re-assembly instructions; and alignment, adjusting, balancing, and checking instructions.

   f. Provide servicing and lubrication schedule for dampers and actuators and list of lubricants required.

   g. Include manufacturers printed operation and maintenance instructions.

   h. Include sequence of operation by BMS manufacturer.

   i. Provide original manufacturer’s parts list, illustrations, assembly drawings, and diagrams required.

   j. Provide control diagrams by controls manufacturer as installed.

   k. Provide BMS contractor’s coordination drawings, with color coded control piping diagrams as installed.

   l. Provide list of original manufacturers' spare parts, current prices, and recommended quantities to be maintained in storage.

   m. Additional requirements as specified in individual Product specification sections.

   n. Provide a listing in Table of Contents for design data, with tabbed dividers and space for insertion of data.

4. Instruction of Designated Facility Personnel

   a. Before final inspection, instruct Owner's designated personnel in operation, adjustment and maintenance of products, equipment, and systems, at agreed upon times.

   b. For equipment requiring seasonal operation, perform instruction for other seasons within six months.

   c. Use operation and maintenance manuals as basis for instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.

   d. Prepare and insert additional data in Operation and Maintenance manual when need for such data becomes apparent during instruction.

5. After all final tests and adjustments have been completed, fully instruct the proper Owner's Representative in all details of operation for equipment installed. Supply qualified personnel to operate equipment for sufficient length of time to assure that Owner's Representative is properly qualified to take over operation and maintenance procedures. Supply qualified personnel to operate equipment for sufficient length of time as required to meet all governing authorities in operation and performance tests.

6. Furnish required number of manuals, in bound form containing data covering capacities, maintenance and operation of all equipment and apparatus. Operating instruction shall cover all phases of control and include the following:

   a. <u>Lubrication Schedule</u>: Indicating type and frequency of lubrication required for dampers and actuators.

   b. <u>List of Spares</u>: Recommended for normal service requirements.

   c. <u>Parts List</u>: Identifying the various parts of the equipment for repair and replacement purposes.

   d. <u>Instruction Books</u> may be standard booklets but shall be clearly marked to indicate applicable equipment.

   e. <u>Wiring Diagrams</u>: Generalized diagrams are not acceptable, submittal shall be specifically prepared for this Project.

7. Instruct Owner on the maintenance instructions for draining and protecting chilled water coils in the winter.

F. Display of Maintenance Instructions

1. One set of operating and maintenance instructions shall be neatly framed behind glass and hung adjacent to the equipment concerned.

G. Record Drawings

1. The BMS contractor shall provide a complete set of "as-built" or record drawings. The drawings shall be prepared and delivered to the architect in an acceptable AutoCAD format.

2. The drawings shall indicate:

   a. All BMS work installed exactly in accordance with the original design.

   b. All BMS work installed as a modification or addition to the original design.

   c. The dimensional information necessary to delineate the exact location of all wiring runs that are so concealed as to be untraceable by inspection through the regular means of access established for inspection and maintenance. Where shop drawings have been prepared and approved, the "as-built" drawings shall be cross-referenced to the respective shop drawing.
   d. All wiring routing locations must be shown.

3. As-built record drawings shall include the updating of all equipment schedule sheets.

4. The record drawings shall be reproducible as directed.

5. The BMS Contractor shall make arrangements with the Engineer to obtain design drawings on CD ROM disks in AutoCAD format for use as a basis for the "as-built" drawings. These documents remain the property of Cosentini Associates and shall not be used for any other purpose without expressed, written consent. The contractor shall assume all liabilities resulting from unauthorized use or modifications to the drawings.

6. Prior to developing any "as-built" drawings, the contractor shall coordinate with the Owner and the Architect Engineer the drawing layers, etc., of the CAD drawings.

7. "As-built" information shall be submitted as follows:

   a. CAD drawing files on CD ROM disks in AutoCAD format. The version of AutoCAD to be utilized shall be the version in use by the Engineer at the time of the submission.

   b. Two (2) sets of reproducible drawings.

   c. Three (3) sets of blueprints.

8. The quantity of design drawings which are made available shall in no way be interpreted as setting a limit to the number of drawings necessary to show the required "as-built" information.

9. Progress prints of record drawings shall be submitted monthly during the

construction period for Architect's approval.

10. This trade shall submit the "as-built" set for approval by the building department in a form acceptable to the department, when required by the jurisdiction.

11. The contractor shall provide files on disks in an ASCII format for all schedules, catalog information, installation instructions manuals (information) indexed by system and/or equipment.

12. All equipment and systems require proper identification and tagging, including a system description. This information must be coordinated with all design and shop drawings.

1.12 WARRANTY

A. The Contractor shall warranty the BMS to be free from defects in workmanship and material for a period of one (1) year from the date of acceptance by the Owner. During the warranty period, the Contractor shall furnish all labor to repair or replace all items or components that fail due to defects in workmanship or material. This contractor shall also provide all system software upgrades during the warranty period.

B. The Contractor shall provide an on-line troubleshooting service during the warranty period. The on-line system shall allow the contractor or owner’s agent the ability to interrogate, troubleshoot and correct warranty defects remotely. This system shall be operational 24 hours a day, 365 days a year. If the local manufacturer’s staff cannot resolve the problem, the corporate home office staff shall remotely connect to the system and troubleshoot the warranty defect.

C. The Contractor shall submit a written report within 3 days of all warranty defects, the action taken, and corrections made for each warranty call.

D. Extended Maintenance Contract (Alternates 1 & 2)

1. The requirement for the one year maintenance contract during the warranty period shall be included in the contractor’s base bid.

a. Periodic maintenance (preventive and corrective maintenance). A minimum of one eight (8) hour on-site preventative maintenance days per month shall be provided;

b. Recommended spare parts;

c. Emergency service 24 hours a day, 7 days a week, 365 days per year. Response to emergency calls shall be made within 1 hour by phone and 4 hours on-site. Emergency hours shall not be deducted from preventive maintenance time.

d. “Dial in Services” for troubleshooting via modem 24 hours a day, 7 days per week, 365 days per year. Maximum contractor response time shall be 2 hours.

2. **ALTERNATE 1:** The BMS contractor, as an alternate, shall provide a bid price to extend the maintenance service contract and the warranty, as specified herein, for one (1) additional years following the warranty period.

a. The maintenance services to be provided in both the base bid and the alternate bid shall include, but are not limited to, the following: (refer to equipment schedules, and control drawings to point, equipment and systems count).

b. General

1) All control items are to be maintained even if they were not installed under this contract.

2) The following are the minimum services required by the owner. If additional services to maintain the warranty are requested by the manufacturer or contained in the manufacturer’s maintenance documentation, these services shall be included in both the base and alternate the bid.

3) All maintenance procedures must be as per the manufacturer’s recommendation and not void any warranties.

4) All maintenance procedures must be performed on all systems and equipment based on good standard industry practices or from the owner’s direction.

5) The BMS maintenance contractor must coordinate the PM program with any existing or new maintenance management system whether installed by this contractor or others.

6) The “Standard Terms and Conditions” for this contract will be provided by the facility.

c. Network

1) Monthly

a) The BMS contractor shall provide all software and electronic hardware upgrades as upgrades become available.

b) Provide newly released software documentation updates, field support and technical bulletins.

c) Provide operator support in identifying and resolving problems with software, operations or programming.

2) Quarterly

a) Perform diagnostics on the network to analyze trunk traffic and optimize the trunk.

b) Perform system file back up, field panel database and graphics database backup.

c) Create or modify operator workstation(s) graphics as necessary to reflect changes in the system.

3) Semi-annually

a) Remove cylinder valves and inspect for wear, broken valve spring s, broken valve discs, and damaged valve seats. If necessary, clean and repair.

b) Drain crankcase oil, clean interior of crankcase, and refill with new oil.

c) Inspect cylinder bore to be sure cylinder receiving proper lubrication.

d) Check for loose foundation bolts and tighten if necessary.

e) Drain oil and clean force-feed lubricator oil reservoir.

f) If compressor piston assembly is of the non-lubricated type, remove piston and check piston rings, piston rod and compressor cylinder bore for wear.

g) Remove piston rod packing and piston rod oil scraper ring. Check for wear and clean (if necessary). Important: Don't intermix packing ring or oil scraper ring segment.

4) Annually

a) Remove, clean and inspect inter-cooler tube, bundles, aftercooler tube bundles and clean interior of cooler shells.

b) Drain water and clean cylinder and cylinder water jackets.

c) Check and clean (if necessary) compressor motor.

d) Check and inspect compressor drive belts for wear and adjustment.

e) Check for wear and inspect main bearing, crank bearing, and wrist pin bushings.

f) Check crankshaft counterweights for tightness.

g) The same procedure should be followed for annual inspection as described in daily, monthly and semi-annual inspection information.

d. Primary and Secondary Control Panels

1) Monthly

a) Verify regulated power assembly and battery voltages. Adjust if required.

b) Ensure cabinet is at earth ground potential.

c) Verify proper system electrical ground isolation.

d) Inspect interconnecting cables and electrical connections.

e) Via personal computer operator workstation, exercise controlled devices with manual command functions and verify proper response of connected field hardware. Check for alarms and overrides using note specific alarms and overrides.

f) Inspect HOA switches for proper position. Coordinate activation of HOA switch test w/owner.

g) Perform built-in, field panel diagnostic tests.

h) Perform integrity test and system wide function test through random point checks, commands, selective disabling, and standard field cabinet reports.

i) Note system points that are in override condition and review with building engineer.

j) Note system points that are in alarm condition and review with building engineer.

k) Review personal computer operator workstation(s) log book with engineer.

2) Annually

a) Clean external surfaces of panel enclosure and associated primary and secondary controllers.

b) Exercise point value display and run diagnostic self-test on primary and secondary control panels.

c) Inspect interior surfaces and components of panel enclosure and associated primary and secondary control panels and clean if required. Ensure all mounted devices and plug-in components are securely in place.

d) Evaluate binary and analog points for proper operation and reporting. At the personal computer operator workstation, make a general performance review of all points.

e) Check individual critical points. Determine new or revised calibration coefficients as required. Make adjustments to connected field devices as required.

f) Enter new revised calibration coefficients into software after completing critical point procedures for each primary or secondary control panel.

g) Upgrade control panel firmware and software with new version as available.

h) Review control loops for proper operation at a time when controlled conditions are stable and at setpoint. If necessary, verify or adjust tuning constraints (proportional/integral gains, etc.), setpoints, parameters, and/or reset schedules.

i) Record any parameter values that are different than those shown on program listing.

j) Label and date all field devices that have been changed or added.

e. All Control Valves

1) Semi-Annually

a) Visually inspect all control valves including reheat valves. Repair and/or replace all observed deficiencies including but not limited to leaking valves, improper connection of wiring, etc.

b) Check to ensure control valves are providing a tight shut-off of controlled medium. Replace trim components as required.

c) Operate control valves over full modulation range to ensure proper operation. Adjust as required.

d) Inspect condition of valve actuator. Operate actuator over full modulation range to ensure proper operation. Repair/replace all defective components.

e) If pneumatic actuation, check all pilot positioners. Repair/replace as required.

f. All Control Dampers (including smoke dampers)

1) Semi-Annually

a) Check damper linkage, setscrews, and blade adjustment for proper tightness. Lubricate as required.

b) Operate dampers over full modulation range to ensure proper operation. Adjust as required. Repair/replace all defective components.

c) Inspect condition of damper actuators. Operate actuators over full modulation range to ensure proper operation. Repair/replace all defective components.

d) If pneumatic actuation, check all pilot positioners. Repair/replace as required.

3. Controls Alternate 2: All items included in this alternate shall be identical to Controls Alternate 1, except that the warranty period shall be for five (5) additional years after the initial one year warranty and maintenance period included in the base bid.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work are limited to the following:

1. Honeywell (Excel 5000)
2. Johnson Controls (Metasys)
3. Siemens (System 600 Apogee).

2.2 SYSTEM ARCHITECTURE

A. The Building Management System (BMS) is designed to support the comfort, safety, and productivity of the building's occupants and property. BMS shall integrate multiple building functions including equipment supervision and control, alarm management, energy management, information management, and historical data collection and archiving.

B. The BMS shall use an open architecture and fully support a multi-vendor environment. To accomplish this, the BMS shall be able to use open communication protocol standards, a wide variety of third-party devices, applications via existing vendor protocols, as well as the latest software and network standards.

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, network controllers and operator devices, while re-using existing controls equipment.

D. In order to meet these requirements, the BMS must be capable of many methods of integration, at each tier of the network:

1. First Tier Network:

   a. The first tier network shall be based on a PC industry standard of Ethernet TCP/IP. PC Workstation LAN controller cards shall be standard "off the shelf" products available through normal PC vendor channels, and shall be capable of communicating over all industry standard media types.

   b. The first tier network shall provide communications between operator workstations and first tier network controllers.

   c. The first tier network will be compatible with other facility-wide networks. The first tier shall be capable of being connected to a facility network by way of standard networking practices.

   d. The primary communication bus shall be installed so that a break in any bus does not affect the communications operation of the bus.

2. Second Tier Network

   a. The second tier network shall be based on an industry standard open protocol communication method.

   b. The second tier network shall provide communications between Intelligent Building Equipment and first tier network controllers.

3. Integration: The ability of control system components from different manufacturers to connect together and provide coordinated control. Integration shall extend to the operator's workstation software, which shall support user interaction with all control system components. Methods of integration include industry standard protocols such as: BACnet, LonMark/LonTalk, OLE for Process Control (OPC) or integrator interfaces between cooperating manufacturer's systems.

   a. Open protocol integration.

      1) Original Equipment Manufacturer's (OEM) may provide connectivity by adopting the BMS manufacturer's protocol for their product. OEM devices include but are not limited to chillers, boilers, variable frequency drives, power monitoring system, and medical gas.

   b. BACnet Protocol Integration

      1) The protocol used between systems will be BACnet over Ethernet and comply with the ASHRAE BACnet standard 135-1995. Supported media shall include fiber, 10base2, and 10baseT.

2) A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.

3) The network shall conform to BACnet conformance class 4, and provide the ability to monitor and control BACnet system points from the BMS.

c. Industrial Protocol Integration

1) Industrial Standard protocols such as Allen-Bradley Data Highway, Modbus+, or Eurotherm-LIN, and others shall be capable of integrating with the BMS.
2) The MNI software and hardware, in conjunction with the integrated systems, shall translate data from multiple systems into one system and one user interface. The MNI shall allow an operator to monitor and control data and systems through an Operator Workstation (OWS).

d. OPC (OLE for Process Control) Integration

1) Operator Workstations shall utilize an OPC client/server architecture so that real-time data can be passed between other OPC compliant systems.

e. Echelon LON WORKS protocol.

1) LonMark certified controllers communicating over LonTalk networks shall interface with the BMS by connection to the network controller, operator workstation, or first tier network.

f. Hardwired

1) Analog and digital signal values shall be passed from one system to another via hardwired connections.

E. The BMS is required to interact with equipment such as chillers or boilers that are provided by other trades. The BMS Contractor shall furnish appropriate equipment and connections to properly integrate these devices. The specific method of integration and the compatible equipment manufacturers shall be stipulated in the BMS Contractor’s proposal, and submittals. It is the responsibility of the General Contractor to ensure that compatible equipment is provided.

2.3 OPERATOR INTERFACE

A. Personal Computer Operator Workstation Hardware

1. Provide (1) workstation located in the 1st floor maintenance office. Location shall be confirmed with Owner.

2. Personal computer operator workstation(s) shall be provided for command entry, information management, network alarm management and database management functions. All real-time control functions shall be resident in the DDC Controllers to facilitate greater fault tolerance and reliability.

3. Each workstation shall consist of the following, at a minimum:

   a. Full tower case personal computer with the latest Pentium processor, 128 MB RAM, 10 GB hard drive and controller, 3-l/2" diskette drive, read/write CD ROM drive, 2 GB MB internal tape drive, mouse and 101-key enhanced keyboard.

   b. Color monitor with SVGA display and a diagonal screen measurement of no less than seventeen inches (17"). Separate controls shall be provided for color, contrasts and brightness. The screen shall be non-reflective. Minimum resolution of 1280 x 1024, .26 or better dot pitch and 72 Hz minimum vertical refresh rate or maximum resolution. 65k colors.

4. Provide a color printer at one (1) workstation for printing of critical alarms, operator transactions, system repots, and any other screen displays. The owner shall choose the workstation to be connected to the color printer. The printer shall have the following requirements at a minimum:

   a. Color laser jet with 2400 x 1200 dpi resolution.

   b. 32K Buffer to store complete graphics for printing.

B. Personal Computer Operator Workstation Software

1. General

   a. Provide software which includes the following:

      1) Scheduling and override of building operations.

      2) Collection and analysis of historical data.

      3) Editing, programming, storage and downloading of controller databases, programs, and parameters.

   b. A 32-bit, multi-tasking Microsoft Windows NT or Windows 2000 environment that allows the user to run several applications simultaneously. Other Windows applications shall run simultaneously with the BMS software including but not limited to Word, Excel, Access, etc.

   c. Provide a user interface that shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection.

d. Operator specific password access protection shall allow the user to limit workstation control, display and data base manipulation capabilities for each object in the system. An object shall be defined as any input or output point, setpoint, system program, etc. The operator privileges shall "follow" the operator to any workstation or Primary Control Panel that the operator logs on to. Provide a minimum of 200 passwords.

e. Operators will be able to perform only those commands on the objects available based on their respective passwords. Menu selections displayed shall be limited to only those items defined for the access level of the password used to log-on.

f. An audit trail report to track system object changes which shall record operator initiated actions. These actions shall include, but not be limited to, changes made by a particular person, changes made to a specific piece of equipment, and/or changes made during a designated time frame. The changes shall be printed and archived for future reference either on command or automatically, at the operator's option. The operator activity tracking data shall be stored in a tamper proof buffer.

g. Software shall allow the operator to perform commands including, but not limited to:

1) Start up and shutdown of equipment.

2) Setpoint adjustment.

3) Add/modify/delete time programming.

4) Enable/disable process execution.

5) Lock/unlock alarm reporting.

6) Enable/disable totalization and/or trending.

7) Override PID loop setpoints.

8) Enter temporary override schedules.

9) Define holiday schedules.

10) Change time/date.

11) Automatic daylight savings time adjustments.

12) Enter/modify analog warning and alarm limits.

2. Reporting

   a. Reports shall be generated and directed to either CRT displays, printers or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:

      1) A general listing of all points in the network

      2) List of all points currently in alarm

      3) List of all points currently in override status

      4) List of all disabled points

      5) List of all points currently locked out

      6) DDC Controller trend overflow warning

      7) List all weekly schedules

3. Scheduling

   a. Provide a graphical spreadsheet-type format for simplification of time-of-day scheduling and overrides of building operations. Provide schedules for 365 days in advance.

   b. Weekly schedules shall be provided for each building zone or piece of equipment with a specific occupancy schedule. Temporary overrides and associated times may be inserted into blocks for modified operating schedules. After overrides have been executed, the original schedule will automatically be restored.

   c. Zone schedules shall be provided for each building zone as previously described. Each schedule shall include all commandable points residing within the zone. Each point may have a unique schedule of operation relative to the zone's occupancy schedule, allowing for sequential starting and control of equipment within the zone. Scheduling and rescheduling of points may be accomplished easily via the zone schedule graphic.

4. Collection and Analysis of Historical Data

   a. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or changes of value, both of which shall be user-definable. Trend data shall be stored on hard disk for future diagnostics and reporting.

b. Trend data report graphics shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or pre-defined groups of at least 6 points. Provide additional functionality to allow any trended data to be transferred directly to an off-the-shelf spreadsheet package such as Excel. This shall allow the user to perform custom calculations such as energy usage, equipment efficiency and energy costs and shall allow for generation of these reports on high-quality plots, graphs and charts.

c. Provide additional functionality that allows the user to view trended data on trend graph displays. Displays shall be actual plots of both historical and/or real-time dynamic point data. A minimum of 10 points shall be viewed simultaneously on a single graph. The user may pause the graph and take "snapshots" of screens to be stored on the hard disk for future recall and analysis. Displays shall include an 'X' axis indicating elapsed time and a 'Y' axis indicating a range scale in engineering units for each point. The 'Y' axis shall have the ability to be manually or automatically scaled at the user's option. Different ranges for each point may be used with minimum and maximum values listed at the bottom and top of the 'Y' axis. All 'Y' axis data shall be color-coded to match the line color for the corresponding point.

1) Static graphs shall represent actual point data that has been trended and stored on disk. Exact point values may be viewed on a data window by pointing or scrolling to the place of interest along the graph. Provide capability to print any graph on the system printer for use as a building management and diagnostics tool.

2) Dynamic graphs shall represent real-time point data. Any point or group of points may be graphed, regardless of whether they have been predefined for trending. The graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of screens to be stored on the workstation disk for future recall and analysis. As with static graphs, exact point values may be viewed and the graphs may be printed.

5. Dynamic Color Graphic Displays

a. All workstation(s) shall be provided with color graphics. All workstation(s) software shall include a graphical viewing and control environment and definition and construction of dynamic color graphic displays.

b. Provide system color graphics for each HVAC system and for each electrical, plumbing and/or piping system that is monitored and/or controlled by the BMS Provide scaled floor plans indicating equipment location, service, and system data as required.

c. Provide color graphic floor plan displays and system schematics for each piece of mechanical equipment, including but not limited to air handling units, chilled water systems and hot water systems to optimize system performance analysis and speed alarm recognition.

d. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands.

e. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.

f. The windowing environment of the PC operator workstation(s)shall allow the user to simultaneously view several graphics at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

g. Graphic generation software shall be provided to allow the user to add, modify or delete system graphic displays via an off the shelf graphics package similar to MicroGraphix Designer.

1) Provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g., constant volume-terminal reheat, VAV, etc.) and electrical symbols.

2) Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout or any other logical grouping of points which aids the operator in the analysis of the facility.

h. Provide an automatically updated, dynamic display of the site-specific BMS architecture indicating the status of primary and secondary controllers, PC workstation(s) and networks.

i. Provide a separate dynamic display page of each HVAC (AHU, AC, chiller, cooling tower, fuel oil, etc.), electrical, and/or plumbing system connected to the BMS.

j. Provide a separate dynamic display page of each piece of terminal equipment (VAV box, fan coil unit, etc.) connected to the BMS.

k. Provide an additional (10) separate dynamic, graphic display pages at each workstation as required by the operating staff to further assist in daily system operations.

l. Graphics shall incorporate all system integration points communicated via hardware or software gateways and/or interfaces. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BMS.

6. System Configuration and Definition

7. All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

   a. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently add, delete or modify any system object including Primary Control Panel(s), operator workstations(s), Secondary Control Panels, reporting definitions, control loops, energy management applications, time and calendar-based programming, totalization, historical data trending, custom control processes, graphic displays, operator passwords, alarm messages, etc.

   b. Definition of operator device characteristics for individual points, applications and control sequences shall be performed using instructive prompting software.

      1) Programming shall be performed with the BMS system online and shall not interfere with BMS system operation.

      2) Inputs and outputs for any process shall not be restricted to a single Primary Control Panel, but shall be able to include data from any and all other network panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).

      3) Provide the capability to backup and store all system databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation(s) are on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate Primary Control Panel. Similarly, changes made at the Primary Control Panels shall be automatically uploaded to the workstation, ensuring system continuity. The user shall also have the option to selectively download changes as desired.

      4) Provide context-sensitive help menus to provide instructions appropriate with operations and applications currently being performed.

C. Telecommunication Capability:

1. Provide all hardware and software to allow operators at dial-up workstation(s) the ability to perform all BMS operator workstation functions as specified herein.

2. Auto-dial/auto-answer communications shall be provided to allow any part of the BMS to communicate with remote operator workstations and/or remote terminals on an intermittent basis via voice-grade telephone lines. Auto-dial Primary Control Panels shall automatically place calls to workstations to report alarms or other significant events.

3. DDC Controllers shall be able to store a minimum of 10 phone numbers of at least 20 digits. Retry a single primary number at a fixed interval until successful.

4. The auto-dial program shall include provisions for handling busy signals, "no answers" and incomplete data transfers. Provide as a minimum 3 secondary numbers when communications cannot be established with the primary device.

5. Operators at dial-up workstations shall be able to perform all control functions, all report functions and all database generation and modification functions as described for workstations connected via the network. Routines shall be provided to automatically answer calls from remote Primary Control Panels. The fact that communications are taking place with remote Primary Control Panels over telephone lines shall be completely transparent to an operator.

6. An operator shall be able to access remote buildings by selection of any facility by its logical name. The workstation dial-up program shall store the phone numbers of each remote site, so the user shall not be required to remember or manually dial telephone numbers.

7. A PC workstation may serve as an operator device on a network, as well as a dial-up workstation for multiple auto-dial Primary Control Panels or networks. Alarm and data file transfers handled via dial-up transactions shall not interfere with network activity nor shall network activity keep the workstation from handling incoming calls.

8. Dial-up communications shall make use of Hayes compatible modems and voice-grade telephone lines. Provide modems rated at 28,800 BPS.

D. Web Based Operator Interface:

1. A graphical interface shall be provided that allows customers to access modify, and control the BMS data and operation via the Internet or Intranet. This interface shall use HTML-based pages to send and receive data from a BMS system to a web browser.

2. The software shall run on the Microsoft Internet Explorer (5.0 or higher) and the Netscape (4.0 or higher) browsers.

3. The interface shall provide four levels of user access. Users will range from read-only access to BMS data (level 4) to having complete access to view and modify BMS data and user accounts (level 1).

4. The interface shall provide a user account utility, complete with a user profile database that includes user ID, encrypted password, access level, and language preference. Operators with the appropriate access level shall be able to add, modify, and delete users within the user profile database, as well as change users' access levels.

5. The interface shall provide a means by which the user can collect items (BMS data points) into "summary" groups. This functionality shall allow authorized users to perform actions ranging from viewing summary groups, to adding items to or deleting items from groups, to creating new summary groups.

6. The web-based interface shall provide the following four screens (or views) and the indicated functionality for each:

   a. Logon screen – allows the user to enter his or her user name and password for logging into the system.

   b. System view – which provides a browser to view the available OPC servers and the branches of information (BMS data points) registered within each.

   c. Summary view – allows the user to view items that have been grouped together into summaries, and allows authorized users to modify or delete groups or items within a group.

   d. User Account view – displays a list of the currently defined users and the corresponding user information. Users with level 2 access can change their passwords. Users with level 1 access can also modify and delete other users' information.

   e. The interface shall provide navigation tools for moving between the System, Summary, and User Account views. In addition, it shall provide tools for gaining access to help and for logging out of the system.

E. Portable Operator's Terminal

1. Provide one (1) portable operator's terminal(s).

2. The POT shall be hand-held and plug directly into individual Primary and Secondary control panels as described below. Provide a user-friendly, English language-prompted interface for quick access to system information.

3. Functionality of the portable operator's terminal connected at any Primary Control Panel:

   a. Logon to system using same operator passwords utilized with PC operator workstation(s) and/or remote modem(s).

   b. Access all network information from Primary Control Panels, if authorized by password level.

   c. Display all point, selected point, and alarm point summaries.

   d. Display all trending and totalization information.

   e. Add, modify, and/or delete any existing or new system point.

   f. Command, change setpoint, enable/disable any system point.

   g. Acknowledge all alarms.

   h. Connect to local logging and report printer.

4. Simultaneous connection of all POTs to any control panel shall not:

   a. Interrupt or interfere with normal network operation in any way.

   b. Prevent alarms from being transmitted.

   c. Preclude any centrally-initiated commands and/or system modification.

2.4 PRIMARY CONTROLLER

A. Primary Control Panel Hardware

1. Spare Capacity

   a. All Primary Control Panels shall be installed with spare points (minimum 2 of each type) and spare memory capacity for future connections. Provide all hardware software, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

   b. Provide all necessary hardware for a complete operating system as required. All hardware shall reside in each Primary Control Panel. Primary Control Panels shall not be dependent upon any higher level computer or another controller for operation.

   c. Each Primary Control Panel shall, at a minimum, be provided with:

      1) Appropriate NEMA rated enclosure.

2) A stand-alone, multi-tasking, multi-user, real-time digital control microprocessor module.

3) Primary Network communication module, if needed for primary network communications.

4) Secondary Network communication module, if needed for secondary network communications.

5) Memory module to accommodate all Primary Control Panel software requirements, including but not limited to, its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, dial-up communications.

6) Data collection/ Data Trend capability.

7) Power supplies as required for all associated modules, sensors, actuators, etc.

8) Input/output point modules as required including spare capacity.

9) Software modules as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable.

10) A portable printer connection port.

11) A portable operator terminal connection port to allow the temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

12) Monitoring of all industry standard types of analog and digital inputs and outputs.

13) Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent primary enclosure.

d. Each Primary Control Panel shall continuously perform self-diagnostics on all hardware and network communications.

e. Each Primary Control Panel shall provide battery backup to support the real-time clock and all memory and programs for a minimum of 1hours. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPS's) of sufficient capabilities for all controllers, panels and operator work station(s).

f. Each Primary Control Panel shall support firmware upgrades without the need to replace hardware.

g. Each controller shall support its associated secondary network(s).

h. Primary control panels shall provide at least two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. Primary control panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

i. Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

2. Primary Control Panel Software

a. Provide all necessary software for a complete operating system as required. All software shall reside in each Primary Control Panel. Primary Control Panels shall not be dependent upon any higher level computer or another controller for operation.

b. All points, panels and programs shall be identified by a point descriptor. The same names shall be displayed at both the Primary Control Panel(s) (via portable terminal, printer or modem) and the PC operator workstation(s). In addition to the point's descriptor and the time and date, the user shall be able to print, display or store an alarm message to more fully describe the alarm condition or direct operator response. Alarm messages shall be coordinated with the Owner.

c. All digital points shall have a user-defined, two-state status indication.

d. Each Primary Control Panel shall, at a minimum, be provided with software for:

1) Two-position control, proportional control, proportional plus integral control, proportional, integral, plus derivative control algorithms, all with automatic control loop tuning.
2) Limiting the number of times each piece of equipment may be cycled within any one-hour period.
3) The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads. Upon the resumption of power, each DDC Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

4) Priority load shedding.

5) Energy management routines including time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start-stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating / cooling interlock, supply temperature reset, priority load shedding, and power failure restart.

6) Custom, job-specific processes defined by the user, to automatically perform calculations and special control routines and sequences of operations.

   (a) It shall be possible to use any system measured point data or status, any system calculated data, a result from any process or any user-defined constant in any controller in the system.

   (b) Any process shall be able to issue commands to points in any and all other controllers in the system.

   (c) Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.

   (d) The custom control programming feature shall be documented via English language descriptors.

7) Generate and receive automatic and manual operator messages and advisories.

8) Interactive HELP function to assist operators connected via POTs and modems.

9) Comment lines for all programs.

10) Distributed, independent alarm analysis and filtering. Reporting of selected alarms during system shutdown and start-up shall be automatically inhibited. A minimum of six priority levels shall be provided for each point.

11) Automatically accumulate and store run-time hours for all digital points.

12) Automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and pulse input type points.

e. Trend data shall be stored at the Primary Control Panels and automatically uploaded to the PC workstation. All trend data shall be available for use in any 3rd party personal computer applications located in the BMS

f. Primary Control Panels shall be able to assign password access and control priorities. The logon password (at any PC workstation(s)or portable operator terminal) shall enable the operator to monitor, adjust and/or control only the systems, programs, primary control panel, and/or secondary control panels that the operator is authorized for. Passwords and priority shall be fully programmable and adjustable.

g. Primary Control Panels shall be able to access any data from, or send control commands and alarm reports directly to, any other Primary Control Panel or combination of controllers on the network without dependence upon a central or intermediate processing device. Primary Control Panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device.

h. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.

1) All alarm or point change reports shall include the point's English language description and the time and date of occurrence.

2) The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. Priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

3) Alarm reports and messages will be directed to a user-defined list of operator devices or PC's.

4) In addition to the point's descriptor and the time and date, the user shall be able to print, display or store the alarm message to more fully describe the alarm condition or direct operator response.

5) Each DDC Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assignable to any number of points in the Controller.

i. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for all points.

1) DDC Controllers shall store point history data for selected analog and digital inputs and outputs:

(a) Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of I minute to 7 days shall be provided.

(b) Trend data shall be stored at the DDC Controllers and automatically uploaded to the workstation. Uploads shall occur based upon user-defined interval, manual command or automatically. All trend data shall be available for use in any 3rd party personal computer applications.

(c) DDC Controllers shall also provide high resolution sampling capability for verification of control loop performance.

j. DDC Controllers shall automatically accumulate and store run-time hours for all digital input and output points.

k. DDC Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.

l. DDC Controllers shall count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly and monthly basis for all points.

2.5 SECONDARY CONTROLLER

A. Secondary Control Panel Hardware

1. Each Secondary Control Panel shall operate as a stand-alone controller capable of performing its user selectable control routines independently of any other controller in the system. Each secondary control panel shall be a microprocessor-based, multi-tasking, real-time digital control processor.

2. Provide a Secondary Control Panel for each of the following types of equipment (if applicable):

a. Constant Air Volume (CAV) boxes

b. Duct-mounted reheat coils

c. Fancoil Units

d. Fan-Powered Variable Air Volume (VAV) Boxes

e. Reheat Coils

f. Supplemental AC units

g. Variable Air Volume (VAV) Boxes

h. Ventilation fans.

i. Other terminal equipment

3. Each Secondary Control Panel shall, at a minimum, be provided with:

a. Appropriate NEMA rated enclosure.

b. A stand-alone real-time digital control microprocessor module.

c. Secondary network communications ability.

d. Power supplies as required for all associated modules, sensors, actuators, etc.

e. Input/output points as required.

f. Software as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable.

g. Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent primary enclosure.

h. Each controller measuring air volume shall include a differential pressure transducer.

i. SCR control of electric heaters.

j. Fan speed controller for fan powered VAV boxes

k. Fan relay for fan powered VAV boxes and fan coil units

4. Each Secondary Control Panel shall continuously perform self-diagnostics on all hardware and secondary network communications. The Secondary Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failure to establish communication to the system.

5. Provide each secondary control panel with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or a minimum of 1-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPSs) of sufficient capacities for all terminal controllers that do not meet this protection requirement. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

6. The secondary control panels shall be powered from a 24 VAC source provided by this contractor and shall function normally under an operating range of +/- 10%, allowing for power source fluctuations and voltage drops. The controllers shall also function normally under ambient conditions of 32 to 122 F (0 to 50 C) and 10% to 90% RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

B. Secondary Control Panel Software

1. Provide all necessary software for a complete operating system as required. All software shall reside in each Secondary Control Panel. Secondary Control Panels shall not be dependent upon any higher level computer or another controller for operation.

2. Each secondary controller shall perform its primary control function independent of primary controller LAN communication, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time data from the primary control panel time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional and integral (PI) control for all applications. All PI parameters shall be field-adjustable by the user via a portable operator’s terminal.

3. Secondary control panels shall support pressure independent terminal boxes including VAV cooling only, VAV with hot water or electric reheat, Fan-powered VAV and Fan-powered VAV with hot water or electric reheat.

All VAV box control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes are not acceptable.

2.6 INPUT DEVICES

A. General

1. All devices and equipment shall be approved for installation.

2. Provide the following field devices as required by the monitoring, control and optimization functions listed elsewhere in this specification.

3. All sensor signals shall be via a 4-20 ma loop.

B. Analog Inputs

1. Temperature Sensors (Not Including Space Temperature Sensors)

a. All temperature sensors shall use RTD (Resistance Temperature Detector) elements. All control signals shall be via a 4-20 ma loop.

b. Calibration adjustments: Zero & Span.

c. Any point, physical or calculated may be designated for trending.

d. Provide Minco or equal.

e. Range:

1) Liquid Immersion Temperature +20/+120 F, +70/+220 F

2) Duct (Single Point) Temperature +20/+120 F, +70/+220 F

3) Duct (Averaging) Temperature +20/+120 F

4) Outside Air Temperature -50/+122 F

2. Space Temperature Sensors

a. RTD or thermistor type

b. Accuracy: ±0.5 F

c. Operating Range: 80 Degree Range Maximum

d. Setpoint Adjustment Range: 55 to 95 F

e. Shall include a terminal jack integral to the sensor assembly to allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator's terminal.

f. Concealed setpoint adjustment switch with software limits.

g. Push-button override switch. The override switch may be locked out, overridden, or limited as to time through software by an authorized operator.

h. Room sensors shall not be located on outside walls.

i. The length of wiring from the space temperature sensor to the controller shall not exceed 100 ft.

3. Humidity Sensors

a. All control signals shall be via a 4-20 ma loop.

b. Sensor Range: 0 to 100%

c. Accuracy: ±2% RH

d. Sensing element: Capacitive sensor

e. Operating Temperature: 15F to 170F

f. Supply Voltage: 12 – 36 VDC

g. Provide Hycal or equal

4. Dewpoint Sensors

a. Accuracy: ± 2.0 Fdp

b. Range: -40/+115 F DP

5. Water Differential Pressure Sensor

a. Provide industrial grade sensors for all differential pressure bypass valves.

b. Factory calibrated for operating range.

c. Rated for system pressure.

d. Manufacturers standard 316 stainless steel.

e. 3 valve manifold and pressure gauges for supply and return pressures.

f. Output shall be 4-20 ma.

g. Rosemount 1151DP, with 316 stainless steel or approved equal.

6. Differential Pressure Transmitter

a. Sensor

1) Accuracy: 5% at 400 to 4000 FPM (2 to 20.4 m/s)
2) Range: 0 to 4000 FPM (0 to 20.4 m/s)

7. Static Pressure Sensor

a. Accuracy: 1% full scale.

b. Transmitter: 4-20mA.

c. Range shall be as required by application.

d. Provide Setra or equal.

8. Airflow Measuring Stations

a. Station

1) Airflow measuring stations required to accomplish the specified control sequence shall be furnished under this section but installed under the sheet metal section. Airflow measuring stations shall be of heavy gauge metal construction, and shall be furnished with an air straightening section with an open face area of not less than 97%.

2) Each airflow measuring station shall measure airflow by means of a network of static and total pressure sensors factory positioned and connected in parallel to produce an averaged velocity pressure. The measured velocity pressure converted to airflow (CFM) shall have an accuracy of 2% of the full scale throughout the velocity range from 700 to 4,000 FPM when measured under ideal laboratory conditions. The location of stations shall meet manufacturer's guidelines.

3) The maximum resistance to airflow shall not exceed 0.6 times the velocity head. The unit shall be suitable to withstand temperatures up to 250F.

4) All interconnecting tubing between the air measuring and any remote metering or control shall be furnished and installed by the supplier of the station. A minimum of one static and one total pressure sensor shall be used for every 16 sq. inches of duct cross sectional area for ducts up to four sq.ft. in cross section. For larger ducts, a minimum of one static and one total pressure sensor shall be used for every 36 sq. inches of duct cross sectional area.

5) Interconnecting sensor manifolds shall equalize and relate each type of sensor measurement into one total pressure and one static pressure metering port. The permanent system pressure loss created by the unit shall not exceed .15 of a velocity head. Each airflow measuring station shall consist of 16-gauge sheet metal casing and an air straightening section with an open face area not less than 97%. The sheet metal contractor shall install air measuring stations.

6) Provide Air Monitor Fan-E or equal with an accuracy of $\pm$ 2%, a turndown of 6 to 1, and no pressure loss across the station.

7) Final locations to be coordinated with sheet-metal contractor and manufacturer to ensure installed actual accuracy meets specifications.

b. Velocity Pressure Sensor For Airflow Measuring Stations

1) Range: 0.1 to 0.5"wg (Size based on ABMS Output).

2) Accuracy: $\pm$ 0.25” W.G.

3) Transmitter: 4 – 20 ma.

9. Analog Water Level Sensors

a. Furnish and install full height, analog level sensors for each location as specified. Sensor shall provide 4-20ma signal in proportion to basin water level. Provide waterproof enclosure and mounting hardware as required.

b. Sensor shall be Drexel Brook or equal.

10. Flow Meters

a. Provide insertion type, turbine flow meters designed to mount through a fully open, 1 inch full bore ball valve supplied by flow meter manufacturer. Meter flow range shall be 2-40 feet/second for liquid service. Meter linearity shall be +/-1% for a 10:1 range. Repeatability shall be 0.10%. Turbine head and stem shall be constructed of stainless steel, bearings shall be tungsten carbide, and housing and flange shall be carbon steel. Housing pressure rating shall be 350 PSI. A D.C. powered, two-wire transmitter shall be mounted on the flow meter. The flow transmitter output shall be a 4-20 madc signal that is linear with flow. Transmitter input shall be from magnetic pickup. Transmitter accuracy shall be 0.25% of span.

b. Provide an isolation valve kit for turbine flow meters, including isolation valve, bypass valve, nipple, etc., to allow service and removal under pressure and while system is operating.

c. Turbine meter shall be Onicon F 1220 or equal.

11. Carbon Dioxide Sensor

a. The carbon dioxide detectors shall be catalytic-bead type with a demonstrated resistance to silicones and reduced sulfur compounds. Detectors shall have a typical life span of three years. The sensors shall have a dual housing with the sensor and transmitter in separate housings, with sensors located up to 50 feet from the transmitter. Housings shall be explosion proof for Class 1, Group B, C and D, Division 1 areas. Input power shall be 250ma at 24VDC. Response time shall be less than 5 seconds to final reading, from a step change in gas concentration. Sensor/transmitter repeatability shall be +/- 1% full scale. Transmitter signal shall be 4-20 ma.

b. The detection system shall be MSA model 487817 or equal.

c. Provide a calibration kit (flow system type) including zero gas and test carbon dioxide gas. Turn over complete kit to owner at warranty start date.

d. Power 24VDC power supply as required from Emergency source.

12. Carbon Monoxide Monitoring and Control System

a. The sensor/transmitter shall be the MSA model 212376 with a range of 0-200 PPM full scale, or equal.

b. The sensor/transmitter shall incorporate a solid-state, semi-conductor type sensor offering a minimum useful life span of 8 years.

c. The sensor/transmitter shall be 3-wire, 4-20 ma design and shall operate on 24Vdc. The output of the unit shall be linearized to the full scale range.

d. The transmitter circuitry shall include full temperature and humidity compensation and shall incorporate a purge cycle to periodically heat the semiconductor to a high temperature to allow recovery from iterferent gases and high CO concentrations.

e. The response time of the unit, accounting for the purge cycle, shall be 150 seconds or less to 90% of a step change in CO level.

f. The sensor unit shall be provided with a suitable Nema enclosure for wall mounting in loading dock area and garage area.

g. Provide a green LED for power on, a red LED for sensor failure, a yellow LED for CO warning level reached and a red LED for CO alarm level reached. LEDs shall be visible from the outside of the unit enclosure.

h. Provide a calibration kit (flow system type) including zero gas and test gas. Turn over complete kit to owner at warranty start date.

i. Power 24VDC power supply as required from Emergency source.

j. Provide one sensor/transmitter per 5,000 square feet of parking garage and loading dock.

13. Outside Air Volume Sensor/Controller

a. Provide an outside airflow measuring and control system utilizing DDC controls as required by the plans and specifications. System shall be designed to provide accurate measurement without upstream and downstream ductwork.

b. Outside airflow measuring and control system shall have a velocity range from 45 ft/min to 6000 ft/min with a minimum accuracy of 5.0%. Each sensor in the array shall be independently processed for velocity value.

c. Provide 0-10 VDC or 4-20 ma signal proportional to velocity to Control Panel. Control Panel shall modulate damper to maintain setpoint.

d. Provide Dybec, Ruskin or equal.

C. Binary Inputs

1. Water Differential Pressure Switches

a. Range: 8 to 70 PSI

b. Differential: 3 PSI

c. Maximum differential pressure: 200 PSI

d. Maximum pressure: 325 PSI

e. Provide Mercoid or equal

f. Shall be used for all pump status specified in the point schedule.

2. Air Differential Pressure Switches

a. Diaphragm type.

b. Die-cast aluminum housing.

c. Adjustable setpoint.

d. Switch rating shall be a minimum of 5 amps at 120 VAC.

e. Switches shall be SPDT.

f. The switch pressure range shall be suited for the application.

g. Provide Dwyer or equal.

3. Freezestats

a. Furnish and install, for each air handling unit with outdoor air connections, a low temperature safety thermostat (freezestat) with a 20 ft. sensing element.

b. There shall be one freezestat per coil section.

c. Element shall be installed in a serpentine fashion across the inlet of the cooling coil in the air stream.

d. Element shall be arranged to stop the unit supply fan and its associated return air fan should the temperature at any point along the sensing element fall below 35°F for an adjustable time period.

e. Low temperature detector shall be automatic reset, DPDT type.

f. Provide manual reset button at primary control panel and time delay relay to lockout fan if freeze condition exists for more than 60 seconds. Time delay relay shall be adjustable up to 5 minutes.

4. Current Sensing Relay

a. Provide and install current sensing relays for all motor status points 5HP and greater. Sensor shall be split core, two wire, loop powered and sized for expected amperage. Unit shall be UL listed. Provide status LEDs for current sensed below setpoint, current sensed above setpoint and loop power failure. The unit shall automatically range itself and have solid state outputs.

D. Miscellaneous Monitoring Systems

1. Energy Metering System

a. Provide energy (chilled, and hot water) electric metering, reporting and tracking system including all meters, sensor and software. The system shall record, store and report energy consumption, integral to the BMS operator workstation(s)software. The software shall be Excel spreadsheet based, and operate in a Windows environment.

b. For all water flow meters, provide supply and return temperature sensors for "Delta-T" calculation of BTU consumption. Monitor total accumulated BTUs, current BTUs, monthly total BTUs, and yearly total BTUs for each location specified or shown. Provide flow meters at main system lines and each air-handling unit coil.

c. 3P/4W Watt Transducer

1) Provide transducer as required. Input signal shall be a maximum of 0-480 Volts and 0-1000 Amps with a corresponding output of 4-20 ma. Sensor shall be sized to be mid-scale amperage at normal conditions. Response time shall be a maximum of 250 sec with an accuracy of +/- 0.5% full scale. The unit shall be field calibratable and be as manufactured by Kele or equal.

d. Current Transformer

1) Provide transducer as required. Input signal shall be a maximum of 0-1000 Amps with a corresponding output of 0-5 Volts. Sensor shall be sized to be mid scale amperage at normal conditions. Response time shall be a maximum of 250 msec with an accuracy of +/- 0.5% full scale. The unit shall be split core and as manufactured by Crompton, or equal.

2. Fuel Oil Meters

a. Provide fuel oil flow meter on fuel oil supply for duplex fuel oil pump set. Meters shall be contacting head type approved for use in fuel oil systems. Monitor total accumulated flow, current flow, monthly total flow, and yearly total flow for each duplex pump set and jockey pump specified or shown.

b. Meter shall be intrinsically safe, explosion proof with a minimum resolution of 10 gallons with G.P.M. range appropriate for application.

3. Water Leak Detection System

a. General

1) Furnish and install a complete water detection system for each area specified. The system shall include electronic alarm and locating modules, sensing cable, graphic maps and all auxiliary equipment. The system shall simultaneously detect the presence of water at any point along the cable's length, sound an alarm, and pinpoint the distance to the leak. The sensing cable shall be of such construction that no metallic parts shall be exposed to the environment. The system shall provide pre-connecterized sensing cable and components. The system shall be UL listed and FM approved.

2) The water leak detection system shall be installed in the following areas: (Add locations for water leak detection system).

3) The system shall be as manufactured by Raychem Corporation or equal.

4) Provide two sets of test instrumentation to owner.

b. Locating leak detection panel (TTB-FA)

1) The alarm and locator module, TTB-FA, shall monitor up to a maximum of 1000 feet of sensing cable. The alarm module shall indicate that water has contacted the sensing cable by sounding an audible alarm, actuating an output relay, sending a proportional 4-20 ma signal to the BMS and displaying the distance from the start of the sensing cable to the start of the first contact with water. The location of the first water contact shall be retained on the display until the cable is dry and the module is updated.

2) The alarm module shall be capable of detecting the presence of a 1 inch leak any where along the cable with a repeatability of +/- 1%.

3) The alarm module shall continuously monitor the sensing cables and interconnecting cables for continuity. Any break in the cable shall generate an audible alarm, activate an output relay and activate a "continuity" LED on the face of the module.

4) The alarm module shall have LED's indicating "power" (green), "alarm" (red) and "continuity" (yellow). The module shall be equipped with exposed test, reset and silence buttons. All other functions shall require key access.

5) The alarm module shall be powered by emergency power.

6) The module enclosure shall be a minimum of 16 gauge steel, flush mounting type.

c. Single point leak detector

1) The alarm module, TTC, shall monitor up to a maximum of 50 feet of sensing cable. The alarm module shall indicate that water has contacted the sensing cable by sounding an audible alarm and actuating an output relay. The relay shall remain activated until the cable is dry and the module is reset.

2) The alarm module shall be capable of detecting the presence of a 1 inch leak anywhere along the cable with a repeatability of +/- 1%.

3) The alarm module shall continuously monitor the sensing cables and interconnecting cables for continuity. Any break in the cable shall generate an audible alarm, activate an

output relay and activate a "continuity" LED on the face of the module.

4) The alarm module shall have LED's indicating "power" (green), "alarm" (red) and "continuity" (yellow).

5) The alarm module shall be powered by emergency power.

6) The module shall be mounted in a field equipment cabinet.

d. Jumper cable

1) Jumper cable shall be used where leak detection cable is not required but continuity is required (in raceways between alarm module and floor surface, etc.). The jumper cable shall be plenum-rated and jacketed with fluoropolymer materials, as per NEC 725-2(b). The jumper cable shall consist of four different color (Y, B, R, G), insulated 18 AWG wires and shall be available in pre-connectorized lengths of 5, 10, 15, 25 and 50 feet.

e. Accessories

1) Provide all end connectors, leader cables, hold down clips, caution tags, spray adhesive (3M 90M) as required.

f. Graphic display map

1) Provide a graphic display map for each room served. The map shall be a 1/8 in = 1.0 ft scaled drawing of the area served, indicating actual equipment locations, floor tile and other points of reference. The actual cable routing shall be clearly marked on the map with actual scaled distances every 10 feet.

2) A dynamic graphic display, equivalent to the aforementioned map, shall be duplicated on the BMS operator workstation. The area in alarm (within 5 feet) shall blink in red until the alarm is cleared.

g. Performance

1) A maximum wetted area of 2 inches of cable, at any point along the entire length of cable, shall activate an alarm.

2) The system shall be continuously monitored for continuity. The loss of continuity shall cause an alarm within 5 seconds.

3) The cable shall be capable of being cleaned with a clean dry cloth, in place.

4) The cable shall dry and reset the module immediately upon removal from free water. No shaking, wiping or mechanical action shall be required.

h. Installation

1) All system components shall be installed in accordance with the manufacturer's recommendations. The manufacturer shall provide necessary installer training and supervision as required.

2) The cable shall be installed on clean, dry finished surfaces only (coordinate access and schedule installation as required) after the possibility of physical damage has been eliminated. The cable shall be fastened to the surface it is monitoring every 4 feet with hold down clips and spray mastic adhesive. Hold down clip installation shall be subject to spot checks during commissioning. If any clip fails, all other clips shall be re-attached and re-tested, at no additional cost.

3) The system shall be commissioned prior to acceptance. Submit a test procedure for approval.

i. Warranty

1) All equipment shall be warranted to the same extent as the BMS system, or per the manufacturer's warranty, whichever is greater.

4. Audio/Visual Alarm Units

a. Provide audio/visual alarm unit(s) that shall be located in each of (2) mechanical rooms, maintenance office, loading dock, and operation center. Verify locations with owner.

b. Each audio/visual alarm unit shall include a 1" x 3" translucent illuminated rectangular alarm blue color light ("BMS Alarm"), a Sonalert horn (hidden), a silence switch with stainless steel cover plate to match mounting surface. When any BMS alarm occurs (as coordinated with facilities personnel), the alarm light shall flash once per second (adjustable) and the horn shall sound. When the silence switch is pushed, the horn will silence and the pilot light shall light continuously until alarm is cleared.

c. The BMS shall monitor the alarm light, horn and silence switch status.

d. Provide 1/8 inch high engraved and painted lettering for operational instructions as required by the owner on the cover plate.

2.7 OUTPUT DEVICES

A. General

1. All devices and equipment shall be approved for installation.

2. Provide the following field devices as required by the monitoring, control and optimization functions listed elsewhere in this specification.

B. Actuation

1. Electric-Only Actuation

a. All valve actuation shall be electric. Pneumatic actuation is not acceptable.

2. Electric Actuation

a. All valve and damper actuation shall be pneumatic except for terminal equipment valves and dampers which shall be electric. Terminal equipment includes:

1) Cabinet Unit Heaters

2) Constant Air Volume (CAV) boxes

3) Duct-mounted reheat coils

4) Fancoil Units

5) Fan-Powered Variable Air Volume (VAV) Boxes

6) Radiation

7) Supplemental AC units

8) Unit Heaters

9) Variable Air Volume (VAV) boxes

3. Incremental Electronic Actuator for Terminal Equipment Valve and/or Damper Actuation.

a. Incremental actuators shall be allowed for terminal equipment only.

b. Actuators shall be proportional, electronic, direct-coupled actuators used for modulating service. Actuators shall be equipped with metal housings and visual stroke indicators.

c. Actuators shall be equipped with a permanent manual adjustment.

d. Minimum Torque: 35 in-lb.

e. Operating Voltage: 24 VAC.

f. Input Signal: 3 wire floating, 0 – 10 VDC, or 4 – 20 ma.

g. Frequency: 50, 60 Hz.

h. Power Consumption: 1.5va maximum.

i. Spring Return Time: 20 seconds maximum.

j. Nominal Force: 90 lb. Minimum.

k. Stroke: 7/32" (5.5 mm) maximum.

l. For use when the maximum media temperature is 230° F.

4. Valve Actuation

a. All valve actuators shall be sized to close against a differential pressure greater than 125% of the design pump head. Where pressure and flow combinations exceed ratings for commercial valves and actuators, industrial class valves and actuators shall be provided.

b. Valve actuators shall provide smooth modulation at design flow and pressure conditions.

c. Valve actuators shall fail-safe in either the normally open or normally closed position in the event of power failure, signal failure or compressed air failure. Fail Safe Positions are as follows:

1) Air-Handling Unit Preheat Valves Normally Open

2) Air-Handling Unit Cooling Valves Normally Closed

3) Air-Handling Unit Heating Valves Normally Open

4) Duct-mounted Reheat Coil Valves Normally Closed

5) All Humidification Valves Normally Closed

6) Radiation Valves Normally Open

7) Unit Heater Valves Normally Open

8) Cabinet Unit Heater Valves Normally Open

d. **Electronic Modulating Actuator for Valves 2" and Smaller**

1) Actuator shall have electronic, proportional control and shall be direct-coupled with spring return.

2) Actuators shall be equipped with a clutch release for manual override and visual and electronic stroke indicators.

3) Operating Voltage: 24 VAC.

4) Input Signal: 4 - 20 ma.

5) Power Consumption: 18 VA maximum.

6) Spring Return Time: 15 seconds maximum.

7) Nominal Force: 225 lb. Minimum.

8) Stroke: 3/4" (20 mm) maximum.
9) For use when the maximum media temperature is 300 F.

e. **Electronic Modulating Actuator for Valves 2-1/2" and Larger**

1) Actuator shall have electronic, proportional control and shall be direct-coupled with spring return.

2) Actuators shall be equipped with a clutch release for manual override and visual and electronic stroke indicators.

3) Operating Voltage: 24 VAC.

4) Input Signal: 4 - 20 ma.

5) Power Consumption: 28va maximum.

6) Spring Return Time: 20 seconds maximum.

7) Nominal Force: 610 lb.

8) Stroke: 1-1/2" (40 mm) maximum.

9) For use when the maximum media temperature is 300° F.

f. Provide emergency power service to all heating valve actuators.

5. Damper Actuation

a. Damper actuators shall have external adjustable stops to limit the stroke in either direction.

b. All damper actuators shall have sufficient power to overcome friction of damper linkage and air pressure acting on louvers and to operate the damper smoothly throughout the entire damper range.

c. Actuators shall be sized with a torque greater than 150% of the design damper torque.

d. Actuators shall have mounting arrangement for location outside of the air stream. The damper actuators shall be mounted on the damper extension so that it is not burned in the wall construction.

e. Damper actuators shall fail-safe in either the normally open or normally closed position in the event of power failure, signal failure or compressed air failure. Fail Safe Positions are as follows:

1)	Outside Air Dampers	Normally Closed
2)	Return Air Dampers	Normally Opened
3)	Exhaust Air Dampers	Normally Closed
4)	F/SM, SM Dampers	Normally Closed

f. **Electric Damper Actuation for Modulating and Two Position Damper Actuation**

1) Provide proportional, electronic, direct-coupled spring return actuators for all automatic dampers used for modulating service. Each actuator shall be equipped with a brushless DC motor, self centering shaft coupling, metal housing, permanent manual override, visual stroke indicators, built in adjustable start and span controls, and shall be sized to operate the damper with a torque greater than 150% of the design damper torque. Provide actuators with the following specifications:

(a) Operating Voltage: 24 VAC

(b) Input Signal: 4-20 ma (modulating), on/off (two position)

(c) Frequency: 50, 60 Hz

(d) Power Consumption: 9 VA Maximum

(e) Spring Return Time: 15 seconds Maximum

(f) Minimum Torque: 144 in-LB

(g) Angular Rotation: 90 Degrees

g. Provide emergency power source main air-handling unit and network room damper actuators.

h. Fire/Smoke Damper Actuation

1) Actuator shall be manufactured and factory-installed by the fire/smoke damper manufacturer.

2) Acceptable manufacturers: Ruskin, Imperial or approved equal.
3) Provide emergency power source.

2.8 CONTROL VALVES

A. General

1. All automatic control valves controlled by the central control system (/BMS) shall be furnished by the controls contractor unless noted otherwise in these documents.

2. All automatic control valves shall be installed by the mechanical trade.

3. **The controls contractor shall provide wiring as follows:**

   a. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.

   b. All wiring between the central control system (ATC/BMS) and the valve actuator shall be wired by the controls contractor.

   c. All wiring between the valve actuator and their associated thermostats, pressure switches, control devices, etc. shall be wired by the controls contractor.

   d. All wiring shall comply with code requirements. Segregate high and low voltage wiring & circuits and segregate the FAS and controls (BMS) terminals.

B. Hot Water / Chilled Water Control Valves

1. Single-seated.

2. Fully proportioning with modulating plug or V-port inner valves.

3. Body pressure rating and connection type construction shall conform to fitting and valve schedules**.** The ANSI rating of the valve shall match the ANSI rating of the piping in which the valve is installed. Minimum ANSI rating shall be ANSI 125.

4. Stainless steel stems and trim.

5. Spring loaded Teflon packing with replaceable discs.

6. Quiet in operation.

7. Fail-safe in either normally open or normally closed position in the event of power failure.

8. Capable of operating in sequence with other valves and/or dampers when required by the sequence of operation.

9. Capable of operating at varying rates of speed to correspond to the exact dictates of the controller and variable load requirements.

10. Sized by the control manufacturer and guaranteed to meet the heating and cooling loads as scheduled.
11. Shall be suitable for the pressure conditions and shall be sized to close against 125% of the design pump head.

12. No single valve shall be larger than 2-1/2". Whenever the flow rate is such as to require a valve larger than 2-1/2", then two valves in parallel shall be used, with no one larger than 2-1/2". The valves shall operate sequentially.

13. Where pressure and flow combinations exceed ratings for commercial valves and operators, industrial class valves and operators shall be provided. Control valves shall be sized for a 5 PSI pressure drop at full flow.

C. Differential Pressure Control Valves

1. Provide for all water systems where modulating water flow conditions are required to prevent excessive pump pressure build-up. Provide a valve for each chilled and hot water system. Valve to be globe type. Provide valves 2" and smaller with screwed end bodies and provide valves 2-1/2" and larger with flanged ends.

D. Butterfly Valves

1. Furnish automatic butterfly valves for isolation requirements as shown on the drawings or required herein.

2. Butterfly valves shall be have body ratings in accordance with the piping specifications.

3. Valves shall be high performance, fully lugged with carbon steel body ANSI 300 as required by pipe specifications.

4. Valves shall be bubble tight with 316 stainless steel disc, stainless steel shaft and reinforced Teflon seat.

5. If electric actuation is utilized, actuators shall be fail in place with factory mounted open and closed position limit switches mounted.

6. Provide fail in place, electric actuators with waterproof enclosure and crankcase heater for actuator and accessories mounted outside.

7. Provide manual override hand wheels for each valve.

8. Valves shall be Jamesbury 830L or equal.

9. Butterfly valves will only be approved for cooling tower bypass and all two-position (open or close) applications.

10. Valves must have lug type body connections.

2.9 DAMPERS

A. Automatically Controlled Dampers

1. Temperature control manufacturer shall provide all actuated dampers which do not have either a fire and/or smoke rating and shall comply with the following:

   a. Dampers shall be of the louver type with neoprene or vinyl edged blades and end seals.

   b. Louver blades shall be #16 gauge galvanized steel, maximum 8" in width.

   c. Frames shall be minimum 4" reinforced flat galvanized steel with welded corners and stiffening and provisions for end seals.

   d. All rods shall be non-corrosive material with provision for positive interlocking of blades and actuators on the shaft.

   e. Where local codes require fire dampers on outside air intakes, rods shall not be of aluminum construction.

   f. All bearings shall be nylon or Teflon.

   g. All hardware shall be of non-corrosive material.

   h. Two position dampers may be of the parallel-blade type. Modulating dampers shall be of the opposed-blade type.

   i. Provide solid stops on all sides of the frames against which the louver shall close in order to provide maximum 2% leakage at 5" static pressure.

   j. Automatic damper actuators shall be limited to a minimum of one every sixty square feet for two-position type and one every forty square feet for modulating type.

   k. Damper actuators shall meet the same requirements as valve actuators with respect to operating at variable rates of speed, etc., and shall have external adjustable stops to limit the stroke in either direction.

   l. All damper actuators shall be of the neoprene or rubber diaphragm piston type, with sufficient power to overcome friction of damper linkage and air pressure acting on louvers and with mounting arrangement for location outside of the air stream, wherever possible.

B. Fire/Smoke Dampers

1. Dampers shown on drawings designated as "F/SM" shall comply with the following:

a. All fire/smoke dampers shall have a UL label.

b. Dampers shall be provided with factory-installed, UL-rated full sleeves.

c. Provide airfoil or "V" Blade damper blades supported with shafts and stainless steel bearings to allow daily operation.

d. Provide intermediate supports and bearings for damper blades more than 36" long. They shall conform to UL Standard 555 and 555S as leakage rated dampers in smoke control systems and when closed shall be the equivalent of a 1 ½ hour fire damper.

e. Leakage shall conform to Class 2 with maximum leakage of 10 CFM/Sq. Ft. at 1" W.G.

f. The damper manufacturer shall provide damper actuators.

g. All dampers shall be provided with position indicator switches to enable remote status of open or closed positions, however, only those dampers designated in the plans and specifications as F/SM (HS), which indicate that they will be controlled from a central fire command station will be wired for remote status and remote open/closed operation. This central fire command shall provide additional and overriding control of all F/SD's and SD's, which shall also be controllable via central BMS. F/SD and SD f ire control panel shall be by this contractor and located per plans. Control panel shall also include start/stop/starters of all fans (with associated control dampers. This contractor is responsible for coordination and relay interlock of BMS and remote fire control panel with building fire alarm system.

h. Dampers that are controlled from a central fire command station shall:

1) Be provided with a 212°F heat sensor with normally closed contacts (manual reset) to close and lock damper if open.

2) Additionally, dampers shall be factory-equipped with a second normally closed heat sensor correlating to the operator/actuator degradation temperature classification (250°F. to 350°F., depending on actuator utilized). The second sensor is wired through a manual override switch on the central fire command station.

3) The following will be accepted in lieu of the two firestats described. A resettable bimetallic link which opens on heat permitting damper to close and lock if open. This link may

be re-engaged from fire command station at temperature of 150°F or less.

4) Dampers that are not controlled from a central fire command station shall have a fusible link that melts on heat causing damper to close and lock in a closed position.

C. Smoke Dampers

1. Dampers shown on drawings designated as "SM" shall comply with the following:

a. All fire/smoke dampers shall have a UL label.

b. Dampers shall be provided with factory-installed, UL-rated full sleeves.

c. Provide airfoil or "V" Blade damper blades supported with shafts and stainless steel bearings to allow daily operation.

d. Provide intermediate supports and bearings for damper blades more than 36" long. They shall conform to UL Standard 555 and 555S as leakage rated dampers in smoke control systems and when closed shall be the equivalent of a 1 ½ hour fire damper.

e. Leakage shall conform to Class 2 with maximum leakage of 10 CFM/Sq. Ft. at 1" W.G.

f. The damper manufacturer shall provide damper actuators. If dampers are pneumatically actuated, the damper manufacturer shall provide EP switch.

g. All dampers shall be provided with position indicator switches to enable remote status of open or closed positions, however, only those dampers designated in the plans and specifications as F/SM (HS), which indicate that they will be controlled from a central fire command station will be wired for remote status and remote open/closed operation.

h. Dampers that are controlled from a central fire command station shall:

1) Be factory-equipped with a second normally closed heat sensor correlating to the operator/actuator degradation temperature classification (250°F. to 350°F., depending on actuator utilized). The second sensor is wired through a manual override switch on the central fire command station.

2) The following will be accepted in lieu of the two firestats described. A resettable bimetallic link which opens on heat permitting damper to close and lock if open. This link may be re-engaged from fire command station at temperature of 150°F or less.

D. Installation

1. General

a. All electric operated dampers which have a fire and/or smoke rating shall be furnished by the mechanical contractor. All other electric operated dampers shall be furnished by this Contractor. All dampers shall be installed by the mechanical contractor.

b. The BMS contractor shall furnish damper actuators for all dampers that he furnishes. Where practical, actuators shall be factory mounted by the damper manufacturer. The controls contractor shall provide a terminal strip along side the damper for all dampers he furnishes.

c. The Mechanical contractor shall furnish damper actuators for all dampers that he furnishes. Where practical, actuators shall be factory mounted by the damper manufacturer. The mechanical contractor shall provide a terminal strip along side the damper for all dampers he furnishes.

d. Wiring for motor operated dampers that do not have a fire and/or smoke rating shall be provided by the controls contractor from the damper actuator and any associated end switches and sensors to a terminal strip that is wall mounted along side the damper.

e. The controls contractor shall provide wiring as follows:

1) Between the central control system BMS and the terminal strip for all dampers monitored and/or controlled by the BMS whether or not the controls contractor has furnished the damper.

2) Between the terminal strip for all dampers and their associated thermostats, pressure switches, etc. whether or not the control contractor has furnished the damper.

f. Dampers incorporating multiple sections shall be controlled in unison. Where more than one (1) actuator serves a damper, then the actuators shall be driven in unison and the control wiring shall be provided accordingly.

g. Dampers incorporating multiple sections shall be designed in such a way that the actuators are easily accessible. Under no circumstances shall it be necessary to remove damper sections or structural or other fixtures to facilitate removal of damper motors. Provide access doors wherever necessary to meet this requirement.

In particular, insure that where in-air stream actuators are provided, they are readily accessible.

h. The BMS contractor shall provide all power and control wiring for all automatic, fire/smoke or smoke dampers as required to accomplish the HVAC and smoke control sequences of operation. A portion of this work may also be specified in other areas of the specification. It is the responsibility of the BMS contractor to coordinate this work with the other trades. Any work not performed by others will be the ultimate responsibility of the BMS contractor. The fire alarm system shall be able to open or close each damper, regardless of BMS commands.

i. The following table summarizes the trade responsibilities with respect to automatic dampers:

	Non-Fire or Smoke Rated Dampers	Fire and/or Smoke Rated Dampers Not Controlled by Fire Alarm System	Fire and/or Smoke rated Dampers Controlled by Fire Alarm System
Furnish Damper	Controls Contractor	Mechanical Trade	Mechanical Trade
Install Damper	Mechanical Trade	Mechanical Trade	Mechanical Trade
Furnish Actuators(s)	Controls Contractor	Mechanical Trade	Mechanical Trade
Install Actuator(s)	Mechanical Trade	Mechanical Trade	Mechanical Trade
Install and furnish terminal strip complete with all relays, wiring, etc.	Controls Contractor	Mechanical Trade	Mechanical Trade
Provide wiring between actuator, end switches, heat terminal strip.	Controls Contractor	Mechanical Trade	Mechanical Trade
Provide wiring from central control system (BMS) to damper terminal strip.	Controls Contractor	Controls Contractor	Controls Contractor
Provide wiring from FAS to damper terminal strip.			Electrical Trade
Furnish 120V main power to electric actuators (see notes below)	Controls Contractor	Controls Contractor	Electrical Trade
Provide wiring from damper terminal strip to terminal strips for interlocked motors, etc.	Controls Contractor	Controls Contractor	Controls Contractor

	Non-Fire or Smoke Rated Dampers	Fire and/or Smoke Rated Dampers Not Controlled by Fire Alarm System	Fire and/or Smoke rated Dampers Controlled by Fire Alarm System
Provide wiring from damper terminal strip directly to thermostats, etc.	Controls Contractor	Controls Contractor	Controls Contractor

NOTES

1. Controls contractor shall have overall responsibility for the complete coordination of the work and the operation of the damper/actuator installation.

2. Provide 120V control power circuits an emergency distribution board for all equipment designated for service under emergency power (see Electrical Drawings). Equipment includes, but is not limited to, all F/SD's, SD's, and associated controllers and control panels. This contractor is responsible for coordinated emergency power circuits with electrician. These circuits will be terminated in a junction box located in each associated mechanical room and shall be used by the controls contractor to supply local control panels and critical equipment.

   These circuits will also be used by the electrical trade to supply dampers, etc. , requiring control by the Fire Alarm System. Final connection from the terminal strips to the actuators, end switches and sensors shall be by the mechanical trade.

   For dampers not requiring control by the fire alarm system and for other non-critical equipment, obtain power from either the emergency circuits as detailed above or from the motor starter terminal trip. All wiring shall be by the controls contractor.

   2. Damper Terminal Strips

      a. Terminal strip(s) shall be provided along side all motorized dampers. If the damper has a smoke and/or fire rating, the terminal strip shall be provided by the Mechanical Trade. If the damper does not have a fire and/or smoke rating then the terminal strip shall be provided by the controls contractor.

      b. Where dampers are furnished by the controls contractor then he shall provide relays, interconnect wiring and other components to meet the requirements detailed below. The terminal strip(s), relays, etc. shall be housed in wall mounted enclosures which meet the specifications detailed for local starter enclosures.

      c. The terminal strip shall be wired such that the Central Control System (BMS) can undertake the following control and monitoring functions:

1) Open Control - A pair of terminals shall be wired such that when a controls (BMS) relay closes a contact pair across these terminals the damper is driven open. If the damper is two position with an actuator which drives closed and springs open on loss of power then these terminals shall not be used. This signal from the Central Control System (BMS) shall be overridden by a close signal from the Fire Alarm System (FAS) Where dampers are interlocked to motors then the wiring shall be to these terminals.

2) Close Control - A pair of terminals shall be wired such that when a controls (BMS) relay closes a contact pair across these terminals the damper is driven closed. If the damper is two position with an actuator which drives open and springs closed on loss of power then these terminals shall not be used. This signal from the Central Control System (BMS) shall be overridden by an open signal from the FAS.

3) Motor Interlock - A pair of terminals shall be wired to an end switch on the actuator such that the contacts between the terminals shall be closed when the damper is fully open and open when the damper is not fully open. This pair of terminals shall be used for interlocking a damper with a motor such that the motor will not be able to start if the damper is not fully open.

3. Purge Dampers

a. For each damper which is to be monitored and/or controlled by the Fire Alarm System (FAS), the damper actuator, heat sensor and end switches shall each be wired by the mechanical trade to a terminal strip(s) mounted adjacent to the damper so that the FAS can undertake the following control and monitoring functions:

1) FAS “Open/Close” Control - The damper will be driven open in response to closure of an FAS relay contact and will spring closed in response to opening of this relay contact.

2) FAS “Override Open” Control (Smoke Purge Dampers Only) - The damper will be re-opened, subsequent to a heat sensor initiated closure, in response to closure of a second FAS relay contact (or re-closure of the first contact for single sensor dampers).

3) FAS “Open/Closed” Status Monitoring Control (Smoke Purge Dampers Only) - End Switch closures will cause activation of FAS “opened” and “closed” relays in response to operation of end switches at both ends of travel.

4) FAS “Override of (BMS)” Control - For each damper requiring both FAS and ATC (BMS) control, the Controls Contractor shall mount an interface relay within 30 circuiting feet of the damper terminal strip, so wired as to permit FAS override of the ATC (BMS) control.

b. The controls contractor's damper manufacturer shall provide all necessary wiring diagrams to the FAS contractors.

c. Dampers furnished by the mechanical trade shall have similar terminal strips to which the controls contractor shall wire where necessary.

d. Comply with code requirements. Segregate high and low voltage wiring & circuits and segregate the FAS and controls (BMS) terminals.

2.10 CONTROL PANELS

A. Field Equipment Cabinets

1. All DDC controllers, transformers, electric relays, static pressure sensors, velocity pressure sensors, manual override switches, etc., shall be mounted in an appropriate NEMA enclosure and factory wired to terminal strips. The enclosure shall be constructed of steel or extruded aluminum and shall be properly rated for the location. Securely mount the enclosures to the wall or floor of the building structure using approved bracing adjacent to each system to be controlled.

2. Cabinets shall allow extra space for installation of future control components.

3. Submit for approval all proposed locations of DDC control and accessory panels.

4. Submit for approval dimensioned shop drawings of the panel equipment layout prior to panel fabrication.

5. Properly label all panel components including wiring and tubing.

B. Air Dryer System

1. Provide in parallel (2) refrigerated air dryers for the compressed air system at each location, one piped as a standby. Each unit shall consist of a hermetically sealed, direct connected refrigerant compressor and motor unit, automatic drain valve, non-toxic refrigerant, automatic expansion valve, condenser, lubrication system insulation, and other items and accessories, contained in a wall mounted cabinet. The air dryers shall be connected in to the high-pressure side of the compressed air line with copper tubing between the air tank and the pressure reducing station. Each unit shall be non-cycling type, with sufficient capacity to chill the compressed air output of one compressor, to a dewpoint of 35 degrees F with an inlet air temperature of 100EF air (based on 110F ambient temperature) required for normal temperature control system operation. Air dryers shall be piped with manual bypass.

2. Provide a compressed air pressure reducing station complete with two (2) air filters, two (2) oil filters, reducing valves, safety valves, isolating valves, gauges, brass piping and fittings. The use of type K copper tubing with brass or copper solder joint fittings is also acceptable for assembling this station. The reducing station shall be wall mounted adjacent to the air compressor and in each MER. Equipment and piping shall be arranged to provide identical parallel paths for the compressed air to be discharged to the temperature control system at the reduced pressure required for the mode of operation.

3. Provide a replaceable media cartridge type particulate and oil filters in the air piping between the refrigerated dryer and the pressure reducing station. Filters shall be so designed that the media can be replaced without removing the entire unit from the piping. A drain, with valve or petcock, shall be provided at the bottom of the filter assembly. Provide, per air pressure reducing station, two (2) pre-filters and two (2) oil filters, each sized for the compressed air requirements. Filters shall provide a dirt and oil free system. Isolation and changeover valves shall permit uninterrupted service during maintenance.

4. Provide 2 pressure reducing valve parallel branches, each branch having a minimum of three, _? pressure reducing valves. These valves shall reduce the air pressure, in stages, from 80 PSI to 30 PSI to 19psi to 15psi. (these pressures are nominal and may differ from manufacturer to manufacturer)

5. Provide high pressure (80 PSI) to each MER.

6. Provide an approved make ASME standard bronze safety valve at the air tank and after each pressure reducing valve. The safety valve at the air tank shall be 3/4?, set at 80 PSI and each safety valve after the primary reducing valve shall be _?, set at 38 PSI. Safety valves after the other pressure reducing valves shall be _?, set approximately 5 PSI higher then the setting of the reducing valve it follows. Safety valves shall be Crosby Valve & Gauge Co., Kunkle Valve Co. or J.E. Lonergan Co.

7. Provide compressed air system sized for system requirements plus 50% spare capacity.

C. Air Gauges

1. Provide air pressure gauges on all main compressed air systems including, main station, air filters, pressure reducing valves, etc. Gauges shall be 2-1/2" in diameter, minimum.

2. Provide air pressure gauges on controlled equipment compressed air signals. Gauges shall be 1-1/2" in diameter, minimum.

D. Pressure Reducing Stations

1. Provide dual pressure reducing stations in each MER. Station shall incorporate air filters, gauges, manual valves and pressure reducing valves to provide low pressure air as required. Station shall be piped to provide 100% standby and be valved to allow maintenance without compressed air shut down.

2.11 NON BMS DEVICES

A. Non-BMS Monitored Devices
   1. Electric Thermostats
      a. Furnish and install all line voltage thermostats for unit heaters, cabinet unit heaters, and/or radiation. Thermostat contacts shall be rated for maximum heater amperage and shall be snap acting, SPDT.

      b. Thermostat shall have a concealed setpoint adjustment.
      c. Thermostat shall have concealed thermometer temperature indication.

   2. Aquastats

      a. Furnish and install strap on aquastats to prevent unit heaters from operating when hot water is not available.

PART 3 - EXECUTION

3.1 DESIGN CRITERIA

A. The Building Management System (BMS) shall be programmed to start and stop the HVAC equipment based on occupancy schedules as coordinated with the owner. The BMS shall also provide equipment interlocks as required.

B. Static pressure safeties shall not be overridden during smoke purge, but other safeties (freezestats) shall be overridden.

C. Each preheat coil section shall be provided with a separate sensor, control loop, output signal, freezestat, and control valve.

D. All control valves that are sequenced shall be provided with dedicated analog outputs or positioning relays, as applicable.

E. All control dampers that are sequenced shall be provided with dedicated analog outputs or positioning relays, as applicable.

F. Fire Alarm Interface for Fans

   1. The Fire Alarm System shall provide outputs to notify the BMS of fire alarms.

   2. All fan systems shall be stopped from the FAS. When the fan system stops, all associated dampers shall close.

3. All return and exhaust fans shall be stopped from the FAS. When the fan stops, all associated dampers shall close.

4. BMS fire control panel shall provide override and start/stop/status of fans (with associated control dampers), F/SD's and SD's as set forth in section 2.9 herein.

G. All safeties shall be capable of being remotely reset from the BMS.

H. All setpoints shall be adjustable from any BMS personal computer operator workstation via single point commands.

I. All reset schedule parameters shall be adjustable from any BMS personal computer operator workstation via single point commands.

J. All inputs and outputs shall be provided with programmable (adjustable) high and low software alarm limits.

3.2 INSTALLATION CRITERIA

A. Space mounted devices are to be identical in appearance. All devices shall be mounted under the same style cover.

B. Room sensors and thermostats shall not be located on outside walls.

C. Provide all relays, switches, sources of electricity and all other auxiliaries, accessories and connections necessary to make a complete operable system in accordance with the sequences specified.

D. Install controls so that adjustments and calibrations can be readily made. Controls are to be installed by the control equipment manufacturer.

E. Mount surface-mounted control devices, tubing and raceways on brackets to clear the final finished surface on insulation.

F. Conceal control conduit and wiring in all spaces except in the Mechanical Equipment Rooms and in unfinished spaces. Install in parallel banks with all changes in directions made at 90 degree angles.

G. Install control valves horizontally with the power unit up. Installation of control valves will be by the mechanical contractor.

H. Unless otherwise noted, install wall-mounted sensors, thermostats and humidistats to meet ADA requirements. Submit device samples, locations, mounting heights and details for approval for all devices.

I. Install outdoor thermostats in perforated tube and sun shield.

J. All relays, electrical wiring, panels, outputs, etc. to make a complete operational system, shall be provided and installed by this section. See sequences of operation for details.

K. All device locations in finished spaces shall be verified with Architect.

L. Component Tags

1. All automatic and manual valves provided by this contractor, shall be identified with 2" diameter brass tags and brass chains. Lettering shall be ½" high, stamped and painted black. Automatic valve tags shall be stamped with the letters "AV" and sequentially numbered. Provide valve schedule and sample tags for approval.

2. All sensors shall be identified with 1"x 3" black labels with white lettering. Lettering shall be 1/4" high. Provide sensor number, HVAC Unit number, part number and sensor range on tag. Submit tag schedule and sample for approval.

3. All panels, auxiliary component panels, transformer panels, etc. provided by this contractor, shall be identified with 2"x 5" black lamacoid labels with engraved white lettering. Lettering shall be ½" high. Provide panel number, HVAC unit number and service on tag. Submit tag schedule and sample for approval.

3.3 ELECTRICAL WIRING

A. The BMS Contractor shall be responsible for all electrical control work associated with the BMS, HVAC and plumbing systems which is not specified as work of others.

1. Perform all wiring in accordance with all local and national codes including the NEC.

2. Install all line voltage wiring, concealed or exposed, in conduit in accordance with the Division 16 specifications, NEC and local building code.

3. All low voltage electrical control wiring and all Primary Network wiring throughout the building shall be run in conduit. Terminal equipment sensors and the secondary network wiring may be run in plenum rated cable above accessible hung ceilings. Plenum cable shall be run parallel to building lines and supported from the building structure (not from duct, pipe or associated hangers) with bridle rings.

4. Provide extension of 120 volt, 20 amp circuits and circuit breakers from emergency power panels for entire system, except terminal equipment, as required.

5. Surge transient protection shall be incorporated in the design of system to protect electrical components in all DDC control panels and operator workstations.

6. Provide all miscellaneous field device mounting and interconnecting control wiring for all mechanical systems including but not limited to the fuel oil system, emergency generators, chillers, water treatment, AC units, condensing units, PIMs, cooling towers, expansion tanks, VFDs, unit

heaters, filtration systems (air and water), terminal units, fan coil units, electric heaters, house tanks, chiller control system, kitchen equipment, fans, H&V, cabinet heaters, hot water heater, ejectors, sump pits, domestic water system, steam PRV stations, underground pipe leak detection system, and plumbing systems.

7. All systems requiring interconnecting control wiring as specified herein, shall have hardwired interlocks and shall not rely on the BMS to operate (e.g. emergency generator to fuel oil pump interlock, emergency generator to ventilation damper, etc.). Interconnecting wiring shall be run in conduits separate from the BMS associated wiring.

8. All wiring for network communication, sensor signals and interlock wiring shall be permanently labeled at a minimum of 10-foot intervals. Label shall indicate BMS manufacturer's name and cable usage. Labels shall be securely fastened and not be damaged during installation. Cable jackets shall also be color coded to indicate application.

9. Cables shall be tagged or labeled at each termination point and in each intermediate junction box, pull box or cabinet through which they pass.

10. All control and power wiring associated with the control of all automatic, fire/smoke or smoke dampers shall be installed in conduit, regardless of voltage. All control and power wiring for relays associated with the control of any automatic, fire/smoke or smoke damper shall be installed in conduit, regardless of voltage.

11. Data communication between separate buildings or facilities shall be via fiber optic cable only.

12. Provide all line and low voltage wiring for the control of all HVAC, plumbing and fire protection motors (whether individual or as part of packaged equipment) and dampers, including wiring for EP's, PE's, relays, control panels, unit heater and cabinet heater control, etc., except as noted below. Provide wiring to interface devices (relays or others) located within 3 feet of each damper requiring direct smoke and fire control by the Fire Protective Alarm (FPA) System in addition to its automatic temperature control operation.

    a. A separate system of wiring, for smoke and fire control of motors which are to be automatically and/or manually controlled by the fire protective alarm (FPA) system will be run to the motor starters or SCU enclosures by the electrical trade.

    b. Wiring, for smoke and fire control of dampers which are to be automatically and/or manually controlled directly by the FPA system (i.e., not in response to motor operation) will be run by the electrical trade. Wiring will include connections to an adequate 120 volt emergency source, and to interface relays provided as part of the automatic temperature control work within 10 feet of each such damper which is also to be controlled as part of the automatic temperature control work.

13. The BMS contractor shall provide wiring:

    a. Between thermostats, aquastats and unit heater motors.

    b. All control and alarm wiring for all control and alarm devices for all Sections of Specifications.

    c. 120 volt, single phase, 60 hertz emergency power to every BMS panel, VAV box controller, BMS console, PIM, CRT, CPU, valve transmission power supplies, annunciator modules, modems, intercom modules, printers and to other devices as required. It is the intent that the entire building management system and all peripheral devices, alarms, etc., shall be operative under emergency power conditions in the building. The power supplies are to be extended in conduit and wire from emergency circuit breakers.

    d. Provide power supply wiring (as required) to all dampers which do not require “direct” (i.e., not in response to motor operation) smoke and fire control by the fire protective alarm (FPA) system.

    e. Provide status function conduit and wiring for equipment covered under this section.

    f. Provide conduit and wiring between the BMS panels and the temperature, humidity, or pressure sensing elements, including low voltage control wiring.

    g. Provide conduit and control wiring for devices specified in this Section.

    h. Provide conduit and signal wiring between motor starters in motor control centers and high and/or low temperature relay contacts and remote relays in BMS panels located in the vicinity of motor control centers.

    i. Provide conduit and wiring between the PC workstation, electrical panels, metering instrumentation, indicating devices, miscellaneous alarm points, remotely operated contractors, and BMS panels, as shown on the drawings or as specified.

    j. Provide electrical wall box and conduit sleeve for all wall mounted devices.

    k. Firestopping shall be provided for all penetrations of conduit, etc. through fire rated walls and floors and other fire rated separations.

    l. Where conduit is required, it shall be steel electric metallic tubing (EMT), except that it shall be galvanized intermediate steel conduit where located within 8'-0" of the floor in mechanical spaces (or is otherwise exposed to mechanical damage), or is intended for embodiment in concrete.

14. Wires and cables shall have characteristics - in compliance with Articles 725 and/or 800 (as applicable) of the National Electrical Code - as described elsewhere in the specifications or drawings for this project, and shall be UL listed in accordance therewith.

15. Where wires and cables are permitted to be run without conduit, they shall be independently supported from the building structure or ceiling suspension systems at intervals not exceeding four feet on center, utilizing cable supports specifically approved for the purpose. Wires and cables shall not rest on or depend on support from suspended ceiling media (tiles, lath, plaster, as well as splines, runners or bars in the plane of the ceiling), nor shall they be supported from pipes, ducts or conduits. Where cables are bundled together, separate bundles shall be provided separately for each type of cabling and separately for each independent system. Bundling and/or supporting ties shall be of a type suitable for use in a ceiling air handling plenum regardless of whether or not installed in a plenum.

16. Utilize #14 A.W.G. THWN conductors minimum throughout for power wiring (120 VAC or greater) except in conjunction with a manual starter. For a manual starter, utilize conductors equal in size to those in the power circuit.

17. Motor control circuit wires may be run in the same conduit as the wires of motor power circuits; however, abide by the following:

    a. Exclude motor control wires from enclosures (other than motor starter enclosures) which contain power circuit overcurrent protection and switching devices;

    b. Exclude motor control wires from pull boxes and junction boxes containing the wires of main and submain feeders.

    c. Utilize auxiliary pull boxes to separate motor control wires from motor power circuit wires at a point before the power circuit wires enter the items from which motor control wires are excluded.

    d. Exclude motor control wires from the same conduits as motor power circuit wires larger than 250 MCM.

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

    a. Wires and Cables:

        1) American Insulated Wire Corporation, Leviton Manufacturing Co.

        2) Brand-Rex Cable Systems, Brintec Corp.

        3) Carol Cable Company, Inc.

        4) Senator Wire & Cable Co.

5) Southwire Co.

6) Belden Division, Cooper Industries

7) Cable & Wire Division, A.T.& T.

8) American Insulation Wire Company.

b. Connectors for Wires and Cables:

1) AFC, Monogram Co.

2) AMP, Inc.

3) Anderson, Square D Co.

4) Electrical Products Division, 3M Co.

5) O-Z/Gedney Unit, General Signal.

c. Connectors and Splices

1) UL-listed factory-fabricated wiring connectors of size, ampacity rating, material, and type and class for application and for service indicated.

19. Examine raceways and building finishes to receive wires and cables for compliance with installation tolerances and other conditions. Do not proceed with installation until unsatisfactory conditions have been corrected.

20. Utilize copper conductors with THWN, THHN or XHHW insulation. Type THHW and THHW-2 shall not be utilized where excluded by conduit sizing. Type THWN shall not be utilized for connection to 100% rated overcurrent devices.

21. Pull conductors into raceway simultaneously where more than one is being installed in same raceway.

22. Use pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation.

23. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

24. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

25. Properly ground all field equipment panels and terminal unit equipment.

3.4 COORDINATION

A. Coordination with Other Trades

1. Piping and duct installation requirements are specified in other Division 15 Sections. Coordinate installation of all devices furnished under this section to be installed by other trades with the appropriate trade.

2. It is the responsibility of this contractor to coordinate with all trades the location of installed equipment and routing of all electrical and pneumatic control conduits and lines.

3. Install control system components to allow for proper service and maintenance of equipment.

B. Work Performance Schedule

1. A time-phased schedule for delivery, installation, and acceptance of components for the complete system shall be prepared. Submit this schedule to the Owner within five (5) days after award of contract. Submit updates and changes to this schedule promptly to the Owner.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

B. Commissioning, Testing and Acceptance

1. Perform a three-phase commissioning procedure consisting of field I/O calibration and commissioning, system commissioning and integrated system program commissioning. Document all commissioning information on commissioning data sheets that shall be submitted prior to acceptance testing. Commissioning work that requires shutdown of system or deviation from normal function shall be performed when the operation of the system is not required. The commissioning must be coordinated with the owner and construction manager to ensure systems are available when needed. Notify the operating personal in writing of the testing schedule so that authorized personnel from the owner and construction manager are present throughout the commissioning procedure.

2. Phase I – Field I/O Calibration and Commissioning

a. Verify that each control panel has been installed according to plans, specifications and approved shop drawings. Calibrate, test, and have signed off each control sensor and device. Commissioning to include, but not be limited to:

1) Sensor accuracy at 10, 50 and 90% of range.

2) Sensor range.

3) Verify analog limit and binary alarm reporting.

4) Point value reporting.

5) Binary alarm and switch settings.

6) Actuator and positioner spring ranges if pneumatic actuation is utilized.

7) Fail safe operation on loss of control signal, pneumatic air, electric power, network communications, etc.

3. Phase II – System Commissioning

a. Each BMS program shall be put on line and commissioned. The contractor shall, in the presence of the owner and construction manager, demonstrate each programmed sequence of operation and compare the results in writing. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracy. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between the specification and the actual performance will be immediately rectified and re-tested.

4. Phase III - Integrated System Program Commissioning

a. Tests shall include, but not be limited to:

1) Data communication, both normal and failure modes.

2) Fully loaded system response time.

3) Impact of component failures on system performance and system operation.

4) Time/Date changes.

5) End of month/ end of year operation.

6) Season changeover.

7) Global application programs and point sharing.

8) System backup and reloading.

9) System status displays.

10) Diagnostic functions.

11) Power failure routines.

12) Battery backup.

13) Smoke Control, vents, in concert with Fire Alarm System testing.

14) Testing of all electrical and HVAC systems with other division of work.

b. Test procedure and documentation shall be as follows:

1) Submit for approval, a detailed acceptance test procedure designed to demonstrate compliance with contractual requirements. This Acceptance test procedure will take place after the commissioning procedure but before final acceptance, to verify that sensors and control devices maintain specified accuracy and the system performance does not degrade over time.

2) Using the commissioning test data sheets, the contractor shall demonstrate each point. The contractor shall also demonstrate 100 percent of the system functions. The contractor shall demonstrate all points and system functions until all devices and functions meet specification.

3) The BMS contractor shall supply all instruments for testing. Instruments shall be turned over to the owner after acceptance testing.

4) All test instruments shall be submitted for approval prior to their use in commissioning.

5) Test Instrument Accuracy:

a) Temperature: 1/4F or 1/2% full scale, whichever is less.

b) High Pressure (PSI): ½ PSI or 1/2% full scale, whichever is less.

c) Low Pressure: 1/2% of full scale (in w.c.)

d) Humidity: 2% RH

e) Electrical: 1/4% full scale

6) After the above tests are complete and the system is demonstrated to be functioning as specified, a thirty-day performance test period shall begin. If the system performs as specified throughout the test period, requiring only routine maintenance, the system shall be accepted. If the system

fails during the test, and cannot be fully corrected within eight hours, the owner may request that performance tests be repeated.

c. Sub Systems shall also be tested and commissioned.

5. Move In Checkout

a. Each floor shall be re-tested 24 hours prior to move in. The test shall ensure all corrective work is complete and all systems are 100% operational.

6. Additional testing, debugging and fine tuning

a. Provide an additional 100 overtime hours of appropriate highest labor cost category to be used at the owner's discretion to test, debug and fine tune the system after occupancy.

C. **Owner System Performance Verification (OSPV)**

1. The systems and equipment shall be fully functional and operational prior to the OSPV process, or the contract(s) will be back-charged accordingly.

2. OSPV is the process in which the contractor fully demonstrates system operation, system performance, proper operation of the sequence of operations, and system equipment to the Owner’s operating staff in the presence of an OSPV agent.

3. After the contractor’s obligations are completed, including system testing, equipment testing, calibration, system demonstration, sequence of operation start-up, training, providing of maintenance and operation manuals, and corrective action for all punchlist items, the OSPV process begins. The BMS contractor shall include in their bid 80 hours (two technicians @ 40 Hours for the OSPV process.

4. Complementary to the BMS contractor’s responsibility to commission the building systems, an OSPV agent will be retained by the Owner. This OSPV agent will provide independent equipment-systems installation inspection and performance verification. The independent verification will be requested prior to final equipment and systems acceptance by the Owner. It should be emphasized that independent systems verification prior to the OSPV process does not negate the BMS contractor’s obligations to full commission the control system.

5. The OSPV agent will verify system installation, operation, performance, and sequences of operation after the BMS contractor provides written notice that the building system is completed, tested, and fully operational. Upon this notification, the OSPV agent will perform the initial verification. The OSPV agent will provide one (1) additional installation and performance verification, upon notification by the BMS contractor that deficiencies identified have been corrected. Any subsequent installation and performance verification will be at the BMS contractor’s expense.

6. All building systems shall be verified under actual and simulated full load conditions.

7. The Owner, Architect, Engineer, and OSPV agent will have input to and be part of the approval process for systems performance verification.

8. The Owner’s staff shall be informed of all system start-up, shutdown, and verification procedures that involve any utility usage or interruption.

9. The BMS contractor’s technicians provided for the OSPV process shall be thoroughly familiar with the OSPV process (start-up, sequence of operation, shutdown, etc.) and the system or equipment required for the OSPV work. The personnel must also be thoroughly familiar with the project specifications and drawings. Convenient technician substitutes for the OSPV process are unacceptable.

10. Under OSPV, the following shall be verified:

    a. Point to point verification of all BMS points.

    b. The sequence of operation for all systems and equipment.

    c. Calibration of all inputs and outputs.

    d. Operation of the compressed air plant.

    e. System programming.

    f. Standard operation procedures (SOP).

11. The OSPV process includes but is not limited to the above items.

3.6 DEMONSTRATION

A. Maintenance Data and Operating Instructions

1. Description - Maintenance and operating manuals in accordance with Section 01010, General Requirements.

    a. Prepare data in the form of an instructional manual.

2. Manual for Equipment and Systems

    a. Each item of equipment and each system: Include description of unit or system, and component parts. Identify function, normal operating characteristics, and limiting conditions. Include performance curves, with engineering data and test, and complete nomenclature and model number of replaceable parts.

    b. Panelboard Circuit Directories: provide electrical service characteristics, controls, and communications.

    c. Include wiring diagrams as installed.

d. Operating Procedures: Includes start-up, break-in and routine normal operating instructions and sequences. Include regulation, control stopping, shutdown and emergency instructions. Include summer, winter, and any other special operating instructions.

e. Maintenance Requirements: Include routine procedures and guide for preventative maintenance, trouble shooting; disassembly repair, re-assembly instructions including alignment, adjusting, balancing, and checking instructions.

f. Provide servicing and lubrication schedule for dampers and actuators. Provide a list of lubricants required.

g. Include manufacturers printed operation and maintenance instructions.

h. Include sequence of operation by controls manufacturer.

i. Provide original manufacturer's parts list, illustrations, assembly drawings, and diagrams.

j. Provide control diagrams by controls manufacturer as installed.

k. Provide contractor's coordination drawings with control piping diagrams as installed.

l. Provide list of original manufacturer's spare parts. Provide a recommendation of quantities to be maintained in storage.

m. Provide additional requirements as specified in individual product specification sections.

3. Instruction of Facility Personnel

a. Before final inspection, instruct Owner's designated personnel in operation, adjustment and maintenance of products, equipment, and systems, at agreed upon times.

b. For equipment requiring seasonal operation, perform instruction for other seasons within six months.

c. Use operation and maintenance manuals as basis for instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.

d. Prepare and insert additional data in Operation and Maintenance manual when need for such data becomes apparent during instruction.

4. After all final tests and adjustments have been completed, fully instruct the proper Owner's Representative in all details of operation for equipment

installed. Supply qualified personnel to operate equipment for sufficient length of time to assure that Owner's Representative is properly qualified to take over operation and maintenance procedures. Supply qualified personnel to operate equipment for sufficient length of time as required to meet all governing authorities in operation and performance tests.

5. Instruct Owner on the maintenance instructions for draining and protecting chilled water coils in the winter.

B. Display of Maintenance Instructions

1. One set of operating and maintenance instructions shall be neatly framed behind glass and hung adjacent to the equipment concerned.

C. Training

1. The Contractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 8:00 a.m. to 4:30 p.m. weekdays.

2. Provide eighty (80) hours of training for Owner's operating and maintenance personnel. 40 hours shall be off site classroom training and 40 hours shall be on-site training. Videotape all sessions and edit each session to 1-hour tapes. Turn over two copies each unedited and edited tape to the Owner. Training shall include:

   a. Explanation of drawings, operator's and maintenance manuals.

   b. Walk-through of the job to locate all control components.

   c. Operator workstation and peripherals.

   d. DDC Controller and ASC operation/function.

   e. Operator control functions including graphic generation, if design includes color graphics, and field panel programming.

   f. Operation of portable operator's terminal, if an operator terminal is provided to the owner as per this specification.

   g. Explanation of adjustment, calibration and replacement procedures.

3. Provide 8 hours of additional training quarterly during warranty period.

4. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the Owner requires such training, it will be contracted at a later date. Provide description of available local and factory customer training. Provide costs associated with performing training at an off-site classroom facility and detail what is included in the manufacturer's standard pricing such as transportation, meals, etc.

3.7 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested by the Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

END OF SECTION 15950

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems, and equipment.

B. All set points referenced in this section are subject to change and shall be adjustable from the BMS Operator Workstation and from a Portable Operators Terminal.

C. Related Sections include the following:

1. Division 15 Section "HVAC Instrumentation and Controls" for control equipment and devices and submittal requirements.

1.3 DEFINITIONS

A. AI - Analog Input

B. ANSI - American National Standards Institute

C. AO - Analog Output

D. ASCII - American Standard Code for Information Interchange

E. AWG - American Wire Gauge

F. BMS - Building Management System

G. CPU - Central Processing Unit

H. CRT - Cathode Ray Tube

I. DAC - Digital to Analog Converter

J. DDC - Direct Digital Control

K. DI - Digital Input

L.	DO	-	Digital Output
M.	EEPROM	-	Electronically Erasable Programmable Read Only Memory
N.	EMI	-	Electromagnetic Interference
O.	FAS	-	Fire Alarm Detection and Annunciation System
P.	HOA	-	Hand-Off-Auto
Q.	IEEE	-	Institute of Electrical and Electronics Engineers
R.	I/O	-	Input/Output
S.	LAN	-	Local Area Network
T.	LCD	-	Liquid Crystal Display
U.	LED	-	Light Emitting Diode
V.	MCC	-	Motor Control Center
W.	NC	-	Normally Closed
X.	NO	-	Normally Open
Y.	OWS	-	Operator Workstation
Z.	OAT	-	Outdoor Air Temperature
AA.	PC	-	Personal Computer
BB.	RAM	-	Random Access Memory
CC.	RFI	-	Radio Frequency Interference
DD.	RH	-	Relative Humidity
EE.	ROM	-	Read Only Memory
FF.	RTD	-	Resistance Temperature Detector
GG.	TCP/IP	-	Transmission Control Protocol/Internet Protocol
HH.	UPS	-	Uninterruptible Power Supply
II.	VAC	-	Volts, Alternating Current
JJ.	VAV	-	Variable Air Volume
KK.	VDC	-	Volts, Direct Current

LL. WAN - Wide Area Network.

1.4 PRIMARY HEATING SYSTEM CONTROL SEQUENCES

A. HOT WATER BOILERS

1. GENERAL:

(a) Service: Main building hot water heating system.

(b) Hot Water Pump sequence details under Pump Control Sequences.

(c) Each boiler shall be come with a factory furnished and installed controller for local control of each boiler.

(d) The BMS contractor shall wire any field control devices furnished with the boiler and installed by the mechanical contractor that could not be factory installed.

(e) Provide individual controls for each boiler.

(f) Totalize runtime of the boilers and alternate lead boiler every 168 hours of operation (adj.).

2. SYSTEM OFF:

(a) Hot Water Pumps: Off.

(b) Boiler: Disabled.

(c) Hot Water Valve: Flow through boiler.

3. SYSTEM START:

(a) The primary hot water system shall be indexed on whenever the outside temperature drops below 50°F (adj) or through a manual command from the BMS.

(b) Combustion air system shall be enabled.

(c) Hot Water Pumps: Boiler circulating pump for active boiler shall start. Lead system pump shall start.

(d) Boiler: Once water flow has proven and the combustion air system has proven the boiler shall be enabled to run under the control of the boiler burner controller.

(e) Hot Water Valve: Flow through boiler.

4. SYSTEM RUN:

   (a) Hot Water Pumps: Boiler circulating pump on. Lead system pump on. Provide lead/lag and staging control of the pumps.

   (b) Boiler: Once enabled the boiler shall operate and control the discharge temperature of the boiler at 180°F (adj) through it's self contained packaged controls.

   (c) Hot Water Valve: Shall modulate between full bypass and full flow through the boiler to maintain the desired hot water system supply temperature. The hot water supply temperature set point shall be reset by outside air temperature while maintaining boiler flue condensing as follows:

   (1)

OAT	Set Point
50°F	110°F
30°F	150°F
0°F	180°F

5. SYSTEM OFF:

   (a) Hot Water Pumps: Off

   (b) Boiler: Disabled.

   (c) Hot Water Valve: Flow through boiler. When the system is indexed off the hot water pumps shall stop.

6. SAFETIES AND ALARMS:

   (a) Any safety shutdown shall allow for local manual reset and restart from the BMS system.

   (b) Boilers shall not be enabled to operate until water flow is proven through water flow switches in hot water supply pipe for each boiler.

   (c) Boilers shall not be enabled to run until combustion air dampers and/or fans are proven to be operating.

   (d) Annunciate supply water temperature alarms to the BMS if the high or low analog limits are exceeded.

   (e) Annunciate common alarm to the BMS from the boiler control panel.

7. FAILURE MODES:

   (a) Hot water valve shall fail to full flow through the boilers.

   (b) Pump Lead/Lag: An automatic lead/lag program shall start the standby pump in the event of a primary system pump failure.

   (c) Pump Failure Alarm: At any time that a pump command does not equal a pump status, except immediately after startup, a pump failure alarm shall be generated on the BMS.

(d) Sensor Failure: Upon the failure of an analog sensor, the system shall be indexed to its “System Off” condition and an alarm shall be annunciated to the BMS.

(e) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

B. PERIMETER RADIATION

1. GENERAL:

(a) Service: General heating (see plans)

2. SYSTEM OFF:

(a) Hot Water Valves: Closed.

3. SYSTEM RUN:

(a) Hot Water Valves: When the outside air temperature drops below 45° F the isolation valves for the perimeter radiation shall open fully and the hot water pumps and heat exchanger must be enabled if not already running.

4. SYSTEM STOP:

(a) Hot Water Valves: When the outside air temperature rises above 47° F the isolation valves shall close fully.

5. FAILURE MODES:

(a) Hot water valve shall fail open.

C. AIR COOLED PACKAGED WATER CHILLERS

1. GENERAL:

(a) Service: Main building chilled water cooling system.

(b) The controls provided by the manufacturer of the chiller shall operate to maintain its programmed chilled water setpoint. The setpoint shall be adjustable from the BMS system through a 4-20 milliamp analog output signal. Start/stop and status shall also be hardwired points to the BMS system primary control panel.

(c) Monitoring shall be via a two-wire BMS network interface to the chiller manufacturer's microprocessor controller (Approximately 50 points per chiller). Use RS-485 or RS-232 communication port for system integration. Chiller manufacturer to provide chiller communication equipment.

(d) The BMS contractor shall furnish, install, and wire all devices necessary for a complete operational chilled water system including but not limited to miscellaneous interlock and control wiring for chillers, refrigerant compressors, pumps, flow switches, etc. The BMS contractor shall mount and wire all components furnished by the chiller manufacturer which are not factory installed. Coordinate requirements with the chiller manufacturer.

(e) All isolation valves shall have individual open and close limit switches to provide positive valve position indication to the BMS.

2. SYSTEM OFF:

(a) Chillers: All Off.

(b) Chilled Water Isolation Valves: Closed

3. SYSTEM START:

(a) Chiller shall start automatically through an outside air temperature interlock or manual command from the BMS.

(b) Upon a need for chilled water, the chiller shall be enabled through the BMS after the lead chilled water pump is started and the necessary valves have been properly positioned. Refer to pump control sequences for further detail.

4. SYSTEM RUN:

(a) The controls provided by the manufacturer of the chiller shall operate to maintain its programmed chilled water supply or return setpoint.

(b) Once started, the chiller shall stay on for a minimum time, determined by the chiller manufacturer.

(c) Provide multiple chiller scheduling to stage chillers ON in order of lowest run time. Chillers shall be staged OFF in order of highest run time.

(d) Additional chillers shall be staged ON in order to meet cooling demand. An additional chiller will be needed if the current chilled water setpoint temperature is unable to be maintained for one (1) minute or more (time is user selectable). Once started, the chillers shall stay on for a minimum time, determined by the chiller manufacturer. The highest run time, on-line chiller shall be staged OFF whenever there is enough cooling capacity of the remaining on-line chillers to carry the cooling load without having to turn that chiller back ON. Provide lead/lag chiller cycling.

(e) Chilled Water Setpoint Reset: The Set point of the chilled water temperature shall be reset to the highest allowable level while maintaining space cooling requirements. Provide chilled water temperature optimization to reduce energy requirements by allowing the chilled water setpoint to increase upward under lower load conditions. Chilled water resetting shall be based on actual load, historical trends and predicted load.

5. SYSTEM STOP:

(a) When the system is indexed off the chiller shall shut down.

6. SAFETIES AND ALARMS:

(a) Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) The BMS shall monitor chilled water supply and return temperatures and generate an alarm at the BMS workstation if high or low alarm limits are exceeded.

(c) The BMS shall monitor the chilled water vent line level and annunciate an alarm if the level drops below a predetermined level.

(d) The BMS shall monitor all chiller control panel alarms.

7. FAILURE MODES:

(a) Chiller Failure: Upon failure of the lead chiller to start or continue operating an alarm shall be annunciated to the BMS.

(b) Sensor Failure: Upon the failure of an analog sensor, the chiller system shall remain in the last position and an alarm shall be annunciated to the BMS.

(c) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

1.5 PUMP CONTROL SEQUENCES

A. HOT WATER PUMPS WITH VARIABLE SPEED DRIVE CONTROL

1. GENERAL:

(a) Service: Main building hot water heating system.

(b) Control electronically with dedicated control panel.

(c) The differential pressure sensor and bypass valve shall be wired back to the same controller that serves the pumps.

2. SYSTEM OFF:

(a) Hot Water Pumps: Off and VFD set to 0%.

(b) Differential Pressure Bypass Valve: Closed.

3. SYSTEM START:

(a) The pump shall be started and stopped via the BMS system based upon an outside air temperature interlock and/or system requirements. The pump variable frequency drive control algorithm shall be enabled whenever the associated pump(s) are enabled.

(b) Hot Water Pump: Start at 0% once isolation valve has been proven open and slowly ramp up to speed as required by the differential pressure sensor.

(c) Differential Pressure Bypass Valve: Closed.

4. SYSTEM RUN:

(a) Provide individual control loops and control outputs for each variable frequency drive. Pressure sensors shall be located just prior to the last load on the each circuit and be wired to the same Control Panel that controls the pump VFD and bypass valve. The differential pressure setpoint shall be individually controlled.

(b) Hot Water Pump: The variable frequency drive shall modulate as necessary to maintain the loop differential pressure setpoint. Before the pump VFD is modulated above the minimum level, the differential pressure bypass valve shall be fully closed.

(c) Differential Pressure Bypass Valve: Modulate open as required to maintain minimum flow requirements when the VFD’s are running at minimum speed setting.

5. SYSTEM STOP:

   (a) When the system is indexed off the hot water pumps shall stop.

   (b) The VFD shall be set to 0%.

   (c) All valves shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

   (a) Any safety shutdown shall allow for local manual reset and restart from the BMS system.
   (b) Annunciate differential pressure alarms to the BMS if the high or low analog limits are exceeded.
   (c) Variable Frequency Drive: The BMS shall monitor and alarm the variable frequency drive RPM, fault alarm, common alarm, bypass status and KW.

7. FAILURE MODES:

   (a) Pump Lead/Lag: An automatic lead/lag program shall start the standby pump in the event of a primary pump failure.
   (b) Pump Failure Alarm: At any time that a pump command does not equal a pump status, except immediately after startup, a pump failure alarm shall be generated on the BMS.
   (c) Power Failure:
      (1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.
      (2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

B. HOT WATER PUMPS WITH CONSTANT SPEED CONTROL

1. GENERAL:

   (a) Service: Boiler circulating pumps.
   (b) Control electronically with dedicated control panel, integrated into boiler controls.
   (c) The differential pressure sensor and bypass valve shall be wired back to the same controller that serves the pumps.

2. SYSTEM OFF:

   (a) Hot Water Pumps: Off.
   (b) Hot Water Boiler Isolation Valve: Closed.

3. SYSTEM START:

   (a) The pump shall be started and stopped in conjunction with the associated boiler via the BMS system based upon an outside air temperature interlock and/or system requirements.

(b) Hot Water Pump: Start the pump once the associated hot water boiler has been enabled.

4. SYSTEM RUN:

(a) Hot Water Pump: The pump shall run contiguously while the boiler is operating.

5. SYSTEM STOP:

(a) When the associated boiler is indexed off the hot water pumps shall stop and isolation valve shall close.

6. SAFETIES AND ALARMS:

(a) Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Annunciate differential pressure alarms to the BMS if the high or low analog limits are exceeded.

7. FAILURE MODES:

(a) Pump Failure Alarm: At any time that a pump command does not equal a pump status, except immediately after startup, a pump failure alarm shall be generated on the BMS. Upon pump failure, associated boiler shall be disabled. Standby boiler/pump shall start.

(b) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

1.6 AIR HANDLING UNIT CONTROL SEQUENCES

A. MIXED AIR VARIABLE VOLUME AIR HANDLING UNIT

1. GENERAL:

(a) Service: Core VAV air-handling unit.

(b) Control electronically with dedicated control panel.

(c) Filter Condition: Monitor differential pressures across filters and annunciate alarm when differential pressure set points are exceeded.

2. SYSTEM OFF:

   (a) Supply and Return Fans: Off.

   (b) Supply and Return Fan Speed Drives: Set to 0%.

   (c) Minimum Outside Air Damper: Closed.

   (d) Economizer Dampers: Closed.

   (e) Cooling Coil Valve: Closed.

   (f) Preheat Coil Valve: Shall modulate to maintain the mixed air plenum temperature at 45° F.

3. SYSTEM START:

   (a) The air-handling unit shall be started based upon a start time optimization program, time of day schedule, or manual command from the BMS.

   (b) When the air-handling unit is indexed to operate, all return air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper status prior to fan start.

   (c) All associated VAV boxes shall be enabled and all fan-powered VAV boxes shall be started prior to the supply fan starting.

   (d) The return fan shall start first. Following a 5-second delay, the supply fan shall start.

4. SYSTEM RUN:

   (a) Unoccupied Heating Mode:

      (1) Supply and Return Fans: Supply and return fans shall run if the space temperature falls below 60° F and continue to run until the space temperature exceeds 64° F. The unit shall run a minimum of ½ hour after start up.

      (2) Minimum Outside Air Dampers: Closed.

      (3) Economizer Dampers: Outside air and exhaust dampers are closed and return air damper is open.

      (4) Cooling Coil Valve: Closed.

(5) Preheat Coil Valve: Modulate to maintain a discharge air temperature at 80° F when the supply and return fans are on.

(6) Static Pressure Control.

(i) The supply fan variable speed drive shall be controlled to maintain the supply static pressure setpoint, as sensed at a point 2/3 downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(b) Unoccupied Cooling Mode:

(1) Supply and Return Fans: Cycle supply and return fans to maintain space temperature at the unoccupied cooling setpoint. The unit shall run a minimum of ½ hour after start up.

(2) Minimum Outside Air Dampers: Closed.

(3) Economizer Dampers (Dry-bulb): Economizer dampers shall be enabled to provide free cooling when the outside air temperature is below 55° F.

(i) Economizer Available: If economizer is available and there is a rise in temperature above temperature setpoint, the outside air damper(s) and/or exhaust air damper(s) shall be modulated open from minimum position to 100% open as necessary to maintain temperature setpoint and airflow set points. The return air damper(s) shall modulate closed as the outside air and exhaust air damper(s) modulate open. If the outside air damper is 100% open and there is a further rise in temperature above temperature setpoint, the outside air damper shall remain 100% open and the cooling valve shall be modulated open as necessary to maintain temperature setpoint. Economizer dampers shall modulate in sequence with the cooling coil valve subject to a mixed air low limit of 50° F.

(ii) Economizer Not Available: Outside air damper shall close, the return air damper shall open and exhaust dampers shall close.

(4) Economizer Dampers (Wet-bulb): Economizer mode shall be available whenever the outside air enthalpy is less than the air handling unit return air enthalpy.

(i) Economizer Available: If economizer is available and there is a rise in temperature above temperature setpoint, the outside air damper(s) and/or exhaust air damper(s) shall be modulated open from minimum position to 100% open as necessary to maintain temperature setpoint and airflow set points. The return air damper(s) shall modulate closed as the outside air and exhaust air damper(s) modulate open. If the outside air damper is 100% open and there is a further rise in temperature above temperature setpoint, the outside air damper shall remain 100% open and the cooling valve shall be modulated open as necessary to maintain temperature setpoint. Economizer dampers shall modulate in sequence with the cooling coil valve subject to a mixed air low limit of 50° F.

(ii) Economizer Not Available: Outside air damper shall close, the return air damper shall open and exhaust dampers shall close.

(5) Cooling Coil Valve: Open when the supply and return fans are on and when economizer is not available.

(6) Preheat Coil Valve: Closed.

(7) Static Pressure Control.

(i) The supply fan variable speed drive shall be controlled to maintain the supply static pressure setpoint, as sensed at a point 2/3 downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(c) Warm-up Mode:

(1) Shall be invoked when the return air temperature is below 60° F upon start-up.

(2) Supply and Return Fans: Supply and return fans shall start and run continuously.

(3) Minimum Outside Air Dampers: Closed.

(4) Economizer Dampers: Outside air and exhaust dampers are closed and return air damper is open.

(5) Cooling Coil Valve: Closed.

(6) Preheat Coil Valve: Shall modulate to maintain the mixed air temperature at 55° F when the supply and return fans are on.

(7) Static Pressure Control:

(i) The supply fan variable speed drive shall be controlled to maintain the supply static pressure setpoint, as sensed at a point 2/3 downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(d) Cool-down Mode:

(1) Shall be invoked when the return air temperature is above 80° F upon start-up.

(2) Supply and Return Fans: Supply and return fans shall start and run continuously.

(3) Minimum Outside Air Dampers: Closed.

(4) Economizer Dampers (Wet-bulb): Economizer mode shall be available whenever the outside air enthalpy is less than the air handling unit return air enthalpy.

(i) Economizer Available: If economizer is available and there is a rise in temperature above temperature setpoint, the outside air damper(s) and/or exhaust air damper(s) shall be modulated open from minimum position to 100% open as necessary to maintain temperature setpoint and airflow set points. The return air damper(s) shall modulate closed as the outside air and exhaust air damper(s) modulate open. If the outside air damper is 100% open and there is a further rise in temperature above temperature setpoint, the outside air damper shall remain 100% open and the cooling valve shall be modulated open as necessary to maintain temperature setpoint. Economizer dampers shall modulate in sequence with the cooling coil valve subject to a mixed air low limit of 50° F.

(ii) Economizer Not Available: Outside air damper shall close, the return air damper shall open and exhaust dampers shall close.

(5) Cooling Coil Valve: Modulate in sequence with the economizer dampers to maintain the discharge air temperature at 55° F at start-up and reset linearly and inversely from 55° F to 65° F as the return air temperature decreases from 80° F to 70° F.

(6) Preheat Coil Valve: Closed.

(7) Static Pressure Control:

(i) The supply fan variable speed drive shall be monitored to maintain the supply static pressure setpoint, as sensed at a point downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(e) Occupied Mode:

(1) Supply and Return Fans: Supply and return fans shall run continuously.

(2) Minimum Outside Air Dampers: The minimum outside air damper shall modulate open to maintain the minimum outside air setpoint as measured by the outside air volume sensor.

(3) Economizer Dampers (Wet-bulb): Economizer mode shall be available whenever the outside air enthalpy is less than the air handling unit return air enthalpy.

(i) Economizer Available: If economizer is available and there is a rise in temperature above temperature setpoint, the outside air damper(s) and/or exhaust air damper(s) shall be modulated open from minimum position to 100% open as necessary to maintain temperature setpoint and airflow set points. The return air damper(s) shall modulate closed as the outside air and exhaust air damper(s) modulate open. If the outside air damper is 100% open and there is a further rise in temperature above temperature setpoint, the outside air damper shall remain 100% open and the cooling valve shall be modulated open as necessary to maintain temperature setpoint. Economizer dampers shall modulate in sequence with the cooling coil valve subject to a mixed air low limit of 50° F.

(ii) Economizer Not Available: Outside air damper shall close, the return air damper shall open and exhaust dampers shall close.

(4) Cooling Coil Valve: Modulate in sequence with the economizer dampers and heating coil valve to maintain the discharge air temperature at setpoint as reset by space temperature. The discharge setpoint shall be reset from 55° F to 65° F linearly as the average of the space temperature sensors decreases from 75° F to 65° F.

(5) Preheat Coil Valve: Shall modulate to maintain the discharge air temperature of 55° F when the supply and return fans are on.

(6) De-humidification Control:

(i) Fully open Cooling coil valve and modulate the re-heat valves to deliver the proper dry bulb temperature discharge air at a reduced wet bulb temperature to satisfy the de-humidification setpoint (adj.).

(7) Static Pressure Control:

(i) The supply fan variable speed drive shall be controlled to maintain the supply static pressure setpoint, as sensed at a point 2/3 downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(8) Provide, install, and wire one return air CO_2 sensor per AHU and monitor from BMS. Whenever CO_2 level exceeds an adjustable setpoint, an alarm shall sound at the BMS and OA damper shall modulate open until alarm is cleared. This automatic program shall be enabled and disabled by the operator through a single command.

5. SYSTEM STOP:

(a) When the air-handling unit is indexed to shut down, the supply and return fans shall stop.

(b) The supply and return speed drives shall be set to 0%.

(c) Dampers, control valves and electric heat shall be indexed to their "System Off" conditions.

6. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Low Outdoor Airflow: If outdoor airflow drops below 5% (adj) of minimum setpoint, as monitored by OA flow sensor, an alarm shall be generated at the BMS.

(c) Low Limit: Manual reset low limit thermostat, mounted upstream of the cooling coil and downstream of the heating coil, shall stop the supply and return fans, close the outdoor air dampers and cooling coil valve and annunciate alarm to the BMS should the coil discharge air temperature fall below 38°F.

(d) High Temperature: Manual reset high limit thermostats, mounted at the discharge and return of the unit, shall stop the supply and return fans, close the outdoor air dampers and cooling coil valve and annunciate alarm to the BMS should the discharge air or return air temperature exceed 135°F.

(e) Low Suction: Low suction pressure switches shall stop the supply and return fans when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(f) High Static: High discharge pressure switches shall stop the supply and return fans when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(g) Variable Frequency Drive: The BMS shall monitor and alarm the variable frequency drive RPM, fault alarm, common alarm, bypass status and KW.

(h) Filter Condition: Monitor differential pressures across filter and annunciate alarm when differential pressure set point is exceeded.

(i) Emergency Shutdown:

(1) Room smoke detector(s) shall stop the supply and return fans and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detectors shall be wired into the building fire alarm system.

(2) The supply and return fans shall be interlocked to shut down upon a command from the building fire alarm system. Dampers and control valves shall be indexed to their “System Off” conditions.

(j) Annunciate off alarms whenever supply or return fan status does not equal start command.

7. FAILURE MODES:

(a) Fan Failure: If the supply or return fan fails to operate, both fans shall shut down and alarm shall be annunciated. Dampers and control valves shall be indexed to their “System Off” conditions.

(b) Sensor Failure: Upon the failure of an analog sensor, associated dampers and control valves shall remain at their last position and alarm shall be annunciated.

(c) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled. Fans and dampers shall operate normally but electric heat shall be disabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(d) Dampers: Economizer dampers shall be provided with spring return actuators to fail to their “System Off” positions.

(e) Valves:

(1) Heating valves shall be provided with spring return actuators to fail open to the coil.

(2) Cooling valves shall be provided with spring return actuator to fail closed to the coil.

(3) Humidity valves shall be provided with spring return actuators to fail closed to the humidifier.

B. MIXED AIR VARIABLE VOLUME AIR HANDLING UNIT

1. GENERAL:

(a) Service: Airside and Landside air floor air-handling units.

(b) Control electronically with dedicated control panel.

(c) Filter Condition: Monitor differential pressures across filters and annunciate alarm when differential pressure set points are exceeded.

2. SYSTEM OFF:

(a) Supply and Return Fans: Off.

(b) Supply and Return Fan Speed Drives: Set to 0%.

(c) Minimum Outside Air Damper: Closed.

(d) Economizer Dampers: Closed.

(e) Cooling Coil Valve: Closed.

(f) Preheat Coil Valve: Shall modulate to maintain the mixed air plenum temperature at 45° F.

3. SYSTEM START:

(a) The air-handling unit shall be started based upon a start time optimization program, time of day schedule, or manual command from the BMS.

(b) When the air-handling unit is indexed to operate, all return air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper status prior to fan start.

(c) All associated VAV boxes shall be enabled and all fan-powered VAV boxes shall be started prior to the supply fan starting.

(d) The return fan shall start first. Following a 5-second delay, the supply fan shall start.

4. SYSTEM RUN:

(a) Unoccupied Heating Mode:

(1) Supply and Return Fans: Supply and return fans shall run if the space temperature falls below 60° F and continue to run until the space temperature exceeds 64° F. The unit shall run a minimum of ½ hour after start up.

(2) Minimum Outside Air Dampers: Closed.

(3) Economizer Dampers: Outside air and exhaust dampers are closed and return air damper is open.

(4) Cooling Coil Valve: Closed.

(5) Preheat Coil Valve: Modulate to maintain a discharge air temperature at 80° F when the supply and return fans are on.

(6) Static Pressure Control.

(i) The supply fan variable speed drive shall be monitored to maintain the supply static pressure setpoint, as sensed at a point downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(b) Unoccupied Cooling Mode:

(1) Supply and Return Fans: Cycle supply and return fans to maintain space temperature at the unoccupied cooling setpoint. The unit shall run a minimum of ½ hour after start up.

(2) Minimum Outside Air Dampers: Closed.

(3) Economizer Dampers (Dry-bulb): Economizer dampers shall be enabled to provide free cooling when the outside air temperature is below 55° F.

(i) Economizer Available: If economizer is available and there is a rise in temperature above temperature setpoint, the outside air damper(s) and/or exhaust air damper(s) shall be modulated open from minimum position to 100% open as necessary to maintain temperature setpoint and airflow set points. The return air damper(s) shall modulate closed as the outside air and exhaust air damper(s) modulate open. If the outside air damper is 100% open and there is a further rise in temperature above temperature setpoint, the outside air damper shall remain 100% open and the cooling valve shall be modulated open as necessary to maintain temperature setpoint. Economizer dampers shall modulate in sequence with the cooling coil valve subject to a mixed air low limit of 50° F.

(ii) Economizer Not Available: Outside air damper shall close, the return air damper shall open and exhaust dampers shall close.

(4) Economizer Dampers (Wet-bulb): Economizer mode shall be available whenever the outside air enthalpy is less than the air handling unit return air enthalpy.

(i) Economizer Available: If economizer is available and there is a rise in temperature above temperature setpoint, the outside air damper(s) and/or exhaust air damper(s) shall be modulated open from minimum position to 100% open as necessary to maintain temperature setpoint and airflow set points. The return air damper(s) shall modulate closed as the outside air and exhaust air damper(s) modulate open. If the outside air damper is 100% open and there is a further rise in temperature above temperature setpoint, the outside air damper shall remain 100% open and the cooling valve shall be modulated open as necessary to maintain temperature setpoint. Economizer dampers shall modulate in sequence with the cooling coil valve subject to a mixed air low limit of 50° F.

(ii) Economizer Not Available: Outside air damper shall close, the return air damper shall open and exhaust dampers shall close.

(5) Cooling Coil Valve: Open when the supply and return fans are on and when economizer is not available.

(6) Preheat Coil Valve: Closed.

(7) Static Pressure Control.

(i) The supply fan variable speed drive shall be monitored to maintain the supply static pressure setpoint, as sensed at a point downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(c) Warm-up Mode:

(1) Shall be invoked when the return air temperature is below 60° F upon start-up.

(2) Supply and Return Fans: Supply and return fans shall start and run continuously.

(3) Minimum Outside Air Dampers: Closed.

(4) Economizer Dampers: Outside air and exhaust dampers are closed and return air damper is open.

(5) Cooling Coil Valve: Closed.

(6) Preheat Coil Valve: Shall modulate to maintain the mixed air temperature at 55° F when the supply and return fans are on.

(7) Static Pressure Control:

(i) The supply fan variable speed drive shall be monitored to maintain the supply static pressure setpoint, as sensed at a point downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(d) Cool-down Mode:

(1) Shall be invoked when the return air temperature is above 80° F upon start-up.

(2) Supply and Return Fans: Supply and return fans shall start and run continuously.

(3) Minimum Outside Air Dampers: Closed.

(4) Economizer Dampers (Wet-bulb): Economizer mode shall be available whenever the outside air enthalpy is less than the air handling unit return air enthalpy.

(i) Economizer Available: If economizer is available and there is a rise in temperature above temperature setpoint, the outside air damper(s) and/or exhaust air damper(s) shall be modulated open from minimum position to 100% open as necessary to maintain temperature setpoint and airflow set points. The return air damper(s) shall modulate closed as the outside air and exhaust air damper(s) modulate open. If the outside air damper is 100% open and there is a further rise in temperature above temperature setpoint, the outside air damper shall remain 100% open and the cooling valve shall be modulated open as necessary to maintain temperature setpoint. Economizer dampers shall modulate in sequence with the cooling coil valve subject to a mixed air low limit of 50° F.

(ii) Economizer Not Available: Outside air damper shall close, the return air damper shall open and exhaust dampers shall close.

(5) Cooling Coil Valve: Modulate in sequence with the economizer dampers to maintain the discharge air temperature at 55° F at start-up and reset linearly and inversely from 55° F to 65° F as the return air temperature decreases from 80° F to 70° F.

(6) Preheat Coil Valve: Closed.

(7) Static Pressure Control:

(i) The supply fan variable speed drive shall be monitored to maintain the supply static pressure setpoint, as sensed at a point downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(e) Occupied Mode:

(1) Supply and Return Fans: Supply and return fans shall run continuously.

(2) Minimum Outside Air Dampers: The minimum outside air damper shall modulate open to maintain the minimum outside air setpoint as measured by the outside air volume sensor.

(3) Economizer Dampers (Wet-bulb): Economizer mode shall be available whenever the outside air enthalpy is less than the air handling unit return air enthalpy.

(i) Economizer Available: If economizer is available and there is a rise in temperature above temperature setpoint, the outside air damper(s) and/or exhaust air damper(s) shall be modulated open from minimum position to 100% open as necessary to maintain temperature setpoint and airflow set points. The return air damper(s) shall modulate closed as the outside air and exhaust air damper(s) modulate open. If the outside air damper is 100% open and there is a further rise in temperature above temperature setpoint, the outside air damper shall remain 100% open and the cooling valve shall be modulated open as necessary to maintain temperature setpoint. Economizer dampers shall modulate in sequence with the cooling coil valve subject to a mixed air low limit of 50° F.

(ii) Economizer Not Available: Outside air damper shall close, the return air damper shall open and exhaust dampers shall close.

(4) Cooling Coil Valve: Modulate in sequence with the economizer dampers and heating coil valve to maintain the discharge air temperature at setpoint as reset by space temperature. The discharge setpoint shall be reset from 55° F to 65° F linearly as the average of the space temperature sensors decreases from 75° F to 65° F.

(5) Preheat Coil Valve: Shall modulate to maintain the discharge air temperature of 55° F when the supply and return fans are on.

(6) De-humidification Control:

(i) Fully open Cooling coil valve and modulate the re-heat valves to deliver the proper dry bulb temperature discharge air at a reduced wet bulb temperature to satisfy the de-humidification setpoint (adj.).

(7) Static Pressure Control:

(i) The supply fan variable speed drive shall be monitored to maintain the supply static pressure setpoint, as sensed at a point downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(8) Provide, install, and wire one return air CO_2 sensor per AHU and monitor from BMS. Whenever CO_2 level exceeds an adjustable setpoint, an alarm shall sound at the BMS and OA damper shall modulate open until alarm is cleared. This automatic program shall be enabled and disabled by the operator through a single command.

5. SYSTEM STOP:

(a) When the air-handling unit is indexed to shut down, the supply and return fans shall stop.

(b) The supply and return speed drives shall be set to 0%.

(c) Dampers, control valves and electric heat shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Low Outdoor Airflow: If outdoor airflow drops below 5% (adj) of minimum setpoint, as monitored by OA flow sensor, an alarm shall be generated at the BMS.

(c) Low Limit: Manual reset low limit thermostat, mounted upstream of the cooling coil and downstream of the heating coil, shall stop the supply and return fans, close the outdoor air dampers and cooling coil valve and annunciate alarm to the BMS should the coil discharge air temperature fall below 38°F.

(d) High Temperature: Manual reset high limit thermostats, mounted at the discharge and return of the unit, shall stop the supply and return fans, close the outdoor air dampers and cooling coil valve and annunciate alarm to the BMS should the discharge air or return air temperature exceed 135°F.

(e) Low Suction: Low suction pressure switches shall stop the supply and return fans when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their "System Off" conditions. The fans shall remain off until the pressure switch is manually reset.

(f) High Static: High discharge pressure switches shall stop the supply and return fans when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their "System Off" conditions. The fans shall remain off until the pressure switch is manually reset.

(g) Variable Frequency Drive: The BMS shall monitor and alarm the variable frequency drive RPM, fault alarm, common alarm, bypass status and KW.

(h) Filter Condition: Monitor differential pressures across filter and annunciate alarm when differential pressure set point is exceeded.

(i) Emergency Shutdown:

(1) Room smoke detector(s) shall stop the supply and return fans and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detectors shall be wired into the building fire alarm system.

(2) The supply and return fans shall be interlocked to shut down upon a command from the building fire alarm system. Dampers and control valves shall be indexed to their "System Off" conditions.

(j) Annunciate off alarms whenever supply or return fan status does not equal start command.

7. FAILURE MODES:

(a) Fan Failure: If the supply or return fan fails to operate, both fans shall shut down and alarm shall be annunciated. Dampers and control valves shall be indexed to their "System Off" conditions.

(b) Sensor Failure: Upon the failure of an analog sensor, associated dampers and control valves shall remain at their last position and alarm shall be annunciated.

(c) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled. Fans and dampers shall operate normally but electric heat shall be disabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(d) Dampers: Economizer dampers shall be provided with spring return actuators to fail to their “System Off” positions.

(e) Valves:

(1) Heating valves shall be provided with spring return actuators to fail open to the coil.

(2) Cooling valves shall be provided with spring return actuator to fail closed to the coil.

(3) Humidity valves shall be provided with spring return actuators to fail closed to the humidifier.

1.7 VENTILATION UNITS CONTROL SEQUENCES

A. OUTDOOR AIR INTAKE FANS WITH EQUIPMENT INTERLOCK CONTROL

1. GENERAL:

(a) Service: See mechanical equipment schedule.

2. SYSTEM OFF:

(a) Outdoor Air Intake Fan: Off.

(b) Damper: Fully closed.

3. SYSTEM START:

(a) Outdoor Air Intake Fan: The fan shall be started through the BMS based upon a start time optimization program, time of day schedule, or manual command. Provide start contact and speed setpoint to each fan variable frequency drive. Drive shall start unloaded and slowly ramp up to speed as required.

(b) Damper: Upon a command to start, all associated outside air dampers, discharge air dampers, smoke dampers, and associated fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

4. SYSTEM RUN:

(a) Outdoor Air Intake Fan: The fan shall be energized whenever an interlocked air handling unit is running. The fan shall run continuously. The fan variable speed drive shall be controlled to maintain the supply CFM setpoint, as sensed by a supply airflow measuring station. The CFM setpoint shall be calculated by adding the CFM requirements of all running, interlocked air handling units. If there is more than one supply fan, provide an airflow monitoring station for each fan.

(b) Damper: Remain full open.

5. SYSTEM STOP:

(a) Outdoor Air Intake Fan: When the fan is indexed to shut down, the outdoor air intake fan shall stop and the fan speed drive(s) shall be set to 0%.

(b) Damper: Dampers shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Low Suction: A low suction pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(c) High Static: A high discharge pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(d) Filter Condition: Monitor differential pressures across filters and annunciate alarm when differential pressure set points are exceeded.

(e) Variable Frequency Drive: The BMS shall monitor and alarm the variable frequency drive RPM, fault alarm, common alarm, bypass status and KW.

(f) Emergency Shutdown:

(1) Duct smoke detector shall stop the outdoor air intake fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detector shall be wired into the building fire alarm system.

(2) The outdoor air intake fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their “System Off” conditions.

7. FAILURE MODES:

(a) Fan Failure: If the exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their “System Off” conditions.

(b) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(c) Dampers: Exhaust dampers shall be provided with spring return actuators to fail to their “System Off” positions.

B. GENERAL EXHAUST FAN GREATER THAN 2000 CFM

1. GENERAL:

(a) Service: See mechanical equipment schedule.

2. SYSTEM OFF:

(a) Exhaust Fan: Off.

(b) Damper: Fully closed.

3. SYSTEM START:

(a) Exhaust Fan: The fan shall be started through the BMS based upon a start time optimization program, time of day schedule, or manual command.

(b) Damper: When the fan is indexed to operate, all exhaust air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

4. SYSTEM RUN:

   (a) Exhaust Fan: Fan shall run continuously.

   (b) Damper: Remain full open.

5. SYSTEM STOP:

   (a) Exhaust Fan: When the fan is indexed to shut down, the exhaust fan shall stop.

   (b) Damper: Dampers shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

   (a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

   (b) Low Suction: A low suction pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

   (c) High Static: A high discharge pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

   (d) Emergency Shutdown:

      (1) Duct smoke detector shall stop the exhaust fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detector shall be wired into the building fire alarm system.

      (2) The exhaust fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their “System Off” conditions.

7. FAILURE MODES:

   (a) Fan Failure: If the exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their “System Off” conditions.

   (b) Power Failure:

      (1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

      (2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(c) Dampers: Exhaust dampers shall be provided with spring return actuators to fail to their "System Off" positions.

C. GENERAL EXHAUST FAN LESS THAN 2000 CFM

1. GENERAL:

(a) Service: See mechanical equipment schedule.

2. SYSTEM OFF:

(a) Exhaust Fan: Off.

(b) Damper: Fully closed.

3. SYSTEM START:

(a) Exhaust Fan: The fan shall be started through the BMS based upon a start time optimization program, time of day schedule, or manual command.

(b) Damper: When the fan is indexed to operate, all exhaust air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

4. SYSTEM RUN:

(a) Exhaust Fan: Fan shall run continuously.

(b) Damper: Remain full open.

5. SYSTEM STOP:

(a) Exhaust Fan: When the fan is indexed to shut down, the exhaust fan shall stop.

(b) Damper: Dampers shall be indexed to their "System Off" conditions.

6. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Emergency Shutdown:

(1) The exhaust fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their "System Off" conditions.

7. FAILURE MODES:

   (a) Fan Failure: If the exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their “System Off” conditions.

   (b) Power Failure:

      (1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

      (2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

   (c) Dampers: Exhaust dampers shall be provided with spring return actuators to fail to their “System Off” positions.

D. GENERAL EXHAUST FAN LESS THAN 2000 CFM NON-BMS LOCAL CONTROL

1. GENERAL:

   (a) Service: See mechanical equipment schedule.

2. SYSTEM OFF:

   (a) Exhaust Fan: Off.

   (b) Damper: Fully closed.

3. SYSTEM START:

   (a) Exhaust Fan: The fan shall be started through the BMS based upon a start time optimization program, time of day schedule, or manual command.

   (b) Damper: When the fan is indexed to operate, all exhaust air dampers, intake air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

4. SYSTEM RUN:

   (a) Exhaust Fan: Fan shall run continuously.

   (b) Damper: Remain full open.

5. SYSTEM STOP:

   (a) Exhaust Fan: When the fan is indexed to shut down, the fan shall stop.

   (b) Damper: Dampers shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Low Suction: Low suction pressure switches shall stop the supply and return fans when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their "System Off" conditions. The fans shall remain off until the pressure switch is manually reset.

(c) High Static: High discharge pressure switches shall stop the supply and return fans when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their "System Off" conditions. The fans shall remain off until the pressure switch is manually reset.

(d) Emergency Shutdown:

(1) Duct smoke detector shall stop the exhaust fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detectors shall be wired into the building fire alarm system.

(2) The exhaust fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their "System Off" conditions.

(e) Smoke Purge:

(1) When smoke purge is required, the FAS shall open the exhaust damper and start the designated smoke purge fan.

7. FAILURE MODES:

(a) Fan Failure: If the exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their "System Off" conditions.

(b) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(c) Dampers: Exhaust dampers shall be provided with spring return actuators to fail to their "System Off" positions.

E. VARIABLE VOLUME EXHAUST FAN WITH STATIC PRESSURE CONTROL

1. GENERAL:

(a) Service: See mechanical equipment schedule.

2. SYSTEM OFF:

(a) Exhaust Fan: Off.

(b) Damper: Fully closed.

(c) Fan Speed Drive: Set to 0%.

3. SYSTEM START:

(a) Exhaust Fan: The fan shall be started through the BMS based upon a start time optimization program, time of day schedule, or manual command.

(b) Damper: When the fan is indexed to operate, all exhaust air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

(c) Fan Speed Drive: Start at 0% and slowly ramp up to speed.

4. SYSTEM RUN:

(a) Exhaust Fan: Fan shall run continuously.

(b) Damper: Remain full open.

(c) Fan Speed Drive: Modulate to maintain the riser static pressure setpoint 2/3 down the riser shaft.

5. SYSTEM STOP:

(a) Exhaust Fan: When the fan is indexed to shut down, the exhaust fan shall stop.

(b) Damper: Dampers shall be indexed to their “System Off” conditions.

(c) Fan Speed Drive: Speed drives shall be set to 0%.

6. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Low Suction: A low suction pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(c) High Static: A high discharge pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(d) Variable Frequency Drive: The BMS shall monitor and alarm the variable frequency drive RPM, fault alarm, common alarm, bypass status and KW.

(e) Static Pressure Alarm: If the static pressure setpoint cannot be maintained and the fan speed drive is at 95% or higher, sound an alarm at the BMS.

(f) Filter Condition: Monitor differential pressures across filters and annunciate alarm when differential pressure set points are exceeded.

(g) Emergency Shutdown:

(1) Duct smoke detector shall stop the exhaust fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detector shall be wired into the building fire alarm system.

(2) The exhaust fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their “System Off” conditions.

7. FAILURE MODES:

(a) Fan Failure: If the exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their “System Off” conditions.

(b) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(c) Dampers: Exhaust dampers shall be provided with spring return actuators to fail to their “System Off” positions.

F. EXHAUST FAN WITH SPACE TEMPERATURE CONTROL

1. GENERAL:

(a) Service: See mechanical equipment schedule.

2. SYSTEM OFF:

(a) Exhaust Fan: Off.

(b) Damper: Fully closed.

3. SYSTEM START:

(a) Exhaust Fan: The fan shall be started whenever the space temperature rises above the space temperature setpoint of 80°F.

(b) Damper: When the fan is indexed to operate, all exhaust air dampers, intake air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

4. SYSTEM RUN:

(a) Exhaust Fan: Fan shall run based on the space temperature sensor.

(b) Damper: Remain full open.

5. SYSTEM STOP:

(a) Exhaust Fan: When the temperature is at or below setpoint the fan shall stop.

(b) Damper: Dampers shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Temperature Alarms: Annunciate space temperature alarms to the BMS if the high or low analog limits are exceeded.

(c) Low Suction: A low suction pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(d) High Static: A high discharge pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(e) Filter Condition: Monitor differential pressures across filters and annunciate alarm when differential pressure set points are exceeded.

(f) Emergency Shutdown:

(1) Duct smoke detector shall stop the exhaust fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detectors shall be wired into the building fire alarm system.

(2) The exhaust fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their “System Off” conditions.

7. FAILURE MODES:

(a) Fan Failure: If the exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their “System Off” conditions.

(b) Sensor Failure: Upon the failure of the analog duct static pressure sensor, fan speed drive shall remain at the last position and an alarm shall be annunciated.

(c) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(d) Dampers: Exhaust dampers shall be provided with spring return actuators to fail to their “System Off” positions.

G. LOADING DOCK EXHAUST FAN WITH CARBON MONOXIDE CONTROL

1. GENERAL:

(a) Service: See mechanical equipment schedule.

2. SYSTEM OFF:

(a) Exhaust Fan: Off.

(b) Damper: Fully closed.

3. SYSTEM START:

   (a) Provide two carbon monoxide sensors per exhaust fan. The fan shall be energized whenever the carbon monoxide level, as sensed by either of the carbon monoxide sensors, exceeds the carbon monoxide setpoint. The BMS shall monitor the CO level at each CO sensor and provide manual fan override control.

   (b) Damper: When the fan is indexed to operate, all exhaust air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

4. SYSTEM RUN:

   (a) Exhaust Fan: Fan shall run continuously.

   (b) Damper: Remain full open.

5. SYSTEM STOP:

   (a) Exhaust Fan: When the fan is indexed to shut down, the exhaust fan shall stop.

   (b) Damper: Dampers shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

   (a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

   (b) Low Suction: A low suction pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

   (c) High Static: A high discharge pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

   (d) Emergency Shutdown:

      (1) Duct smoke detector shall stop the exhaust fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detector shall be wired into the building fire alarm system.

      (2) The exhaust fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their “System Off” conditions.

7. FAILURE MODES:

(a) Fan Failure: If the exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their "System Off" conditions.

(b) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(c) Dampers: Exhaust dampers shall be provided with spring return actuators to fail to their "System Off" positions.

H. SWITCH GEAR ROOM VENTILATION

1. GENERAL:

(a) Service: See mechanical equipment schedule.

2. SYSTEM OFF:

(a) Supply Fan: Off.

(b) Exhaust Fan: Off.

(c) Dampers: Closed.

3. SYSTEM START:

(a) The supply and exhaust fan shall be energized via the space thermostat whenever the space temperature rises above the space temperature setpoint of 80F (adj). Fan shall be de-energized when space temperature is at or below setpoint.

(b) Damper: When the fan is indexed to operate, all outdoor air dampers, exhaust air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

4. SYSTEM RUN:

(a) Supply Fan: Fan shall run continuously.

(b) Exhaust Fan: Fan shall run continuously.

(c) Dampers: Remain full open.

5. SYSTEM STOP:

   (a) Fans shall be de-energized when space temperature is at or below setpoint.

   (b) Dampers: Dampers shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

   (a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

   (b) Temperature Alarms: Annunciate space temperature alarms to the BMS if the space temperature exceeds the space temperature alarm limit of 95F (adj.)

   (c) Low Suction: A low suction pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

   (d) High Static: A high discharge pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

   (e) Filter Condition: Monitor differential pressures across filters and annunciate alarm when differential pressure set points are exceeded.

   (f) Emergency Shutdown:

      (1) Room smoke detector shall stop the fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detector shall be wired into the building fire alarm system.

      (2) The fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their “System Off” conditions.

7. FAILURE MODES:

   (a) Fan Failure: If the supply or exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their “System Off” conditions.

   (b) Power Failure:

      (1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(c) Dampers: Outdoor air and exhaust dampers shall be provided with spring return actuators to fail to their “System Off” positions.

I. NETWORK ROOMS

1. GENERAL:

(a) Service: See mechanical equipment schedule.

(b) The BMS shall monitor flow switches for each transfer vault or network room.

(c) Provide all thermostats, wiring, alarm panels, dampers, etc. as required by Con Edison and division 16.

2. SYSTEM OFF:

(a) Supply Fan: Off.

(b) Exhaust Fan: Off.

(c) Dampers: Closed.

3. SYSTEM START:

(a) Three space thermostats shall be installed per transformer vault or network room. The supply and exhaust fan shall be energized via any one of three space thermostats whenever the space temperature rises above the space temperature setpoint of 80F (adj).

(b) Damper: When the fan is indexed to operate, all outdoor air dampers, exhaust air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

4. SYSTEM RUN:

(a) Supply Fan: Fan shall run continuously.

(b) Exhaust Fan: Fan shall run continuously.

(c) Dampers: Remain open.

5. SYSTEM STOP:

(a) Exhaust Fan: Fan shall be de-energized when space temperature is at or below setpoint.

(b) Dampers: Dampers shall be indexed to their "System Off" conditions.

6. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Temperature Alarms: Annunciate space temperature alarms to the BMS if the high or low analog limits are exceeded.

(c) Low Suction: A low suction pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their "System Off" conditions. The fans shall remain off until the pressure switch is manually reset.

(d) High Static: A high discharge pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their "System Off" conditions. The fans shall remain off until the pressure switch is manually reset.

(e) Filter Condition: Monitor differential pressures across filters and annunciate alarm when differential pressure set points are exceeded.

(f) Emergency Shutdown:

(1) Room smoke detector shall stop the fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detector shall be wired into the building fire alarm system.

(2) The fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their "System Off" conditions.

7. FAILURE MODES:

(a) Fan Failure: If the supply or exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their "System Off" conditions.

(b) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(c) Dampers: Outdoor air and exhaust dampers shall be provided with spring return actuators to fail to their "System Off" positions.

1.8 TERMINAL UNIT CONTROL SEQUENCES

A. VARIABLE AIR VOLUME (VAV) BOX WITH NO REHEAT

1. GENERAL:

(a) Service: See mechanical equipment schedule.

(b) Provide one DDC controller and at least one thermostat for each VAV box.

(c) The minimum and maximum CFM settings shall be those scheduled on the drawings.

(d) The VAV box damper shall not open beyond the maximum CFM setting.

(e) Coordinate factory mounting and wiring of controller, actuator, and transformer with the VAV box manufacturer. The BMS contractor shall be responsible for furnishing, installing, and wiring any controls not furnished, installed, or wired by others that are required for an operational system.

2. SYSTEM OFF:

(a) VAV box damper: Closed.

3. SYSTEM START:

(a) VAV box damper: Modulate open to maintain CFM setpoint.

4. SYSTEM RUN:

(a) System run is determined by the status of the air handling system serving the VAV box.

(b) Unoccupied Heating Mode:

(1) VAV box damper: Modulate to maintain the unoccupied space setback temperature at setpoint.

(c) Unoccupied Cooling Mode:

(1) VAV box damper: Modulate to maintain the unoccupied space setup temperature at setpoint.

(d) Warm-up Mode:

(1) VAV box damper: Modulate to maintain the warm-up space temperature at setpoint.

(e) Cool-down Mode:

(1) VAV box damper: Modulate to maintain the cool-down space temperature at setpoint.

(f) Occupied Mode:

(1) VAV box damper: Modulate to maintain the space temperature at setpoint. As the space temperature rises above the space temperature setpoint, the DDC controller shall modulate the VAV box damper from the minimum to the maximum CFM setting as necessary to maintain the space temperature at setpoint.

(g) Occupied Override Mode:

(1) The VAV box controller shall be programmed for occupancy override. By depressing the occupancy override button located on the space temperature sensor or via a BMS system override, the VAV box shall restore to the “Occupied Mode” condition.

5. SYSTEM STOP:

(a) VAV box damper: Shall be indexed to its “System Off” condition.

6. SAFETIES AND ALARMS:

(a) Annunciate space temperature alarms to the BMS if the high or low analog limits are exceeded.

(b) Annunciate CFM alarms to the BMS if the high and low analog limits are exceeded.

7. FAILURE MODES:

(a) Fan Failure: If the fan serving the VAV box fails to operate, the VAV box damper shall be indexed to its “System Off” condition.

(b) Sensor Failure: Upon the failure of an analog sensor, the VAV box damper shall remain in its last position and an alarm shall be annunciated to the BMS.

(c) Power Failure:

(1) Upon a power failure, the VAV box damper shall remain in it’s last position.

B. SERIES FAN POWERED BOX WITH NO REHEAT

1. GENERAL:

(a) Service: See mechanical equipment schedule.

(b) Provide one DDC controller and at least one thermostat for each FPVAV box.

(c) The minimum and maximum CFM settings shall be those scheduled on the drawings. The FPVAV box damper shall not open beyond the maximum CFM setting.

(d) Coordinate factory mounting and wiring of controller, actuator, and transformer with the FPVAV box manufacturer. The BMS contractor shall be responsible for furnishing, installing, and wiring any controls not furnished, installed, or wired by others that are required for an operational system.

2. SYSTEM OFF:

(a) FPVAV Box Fan: Off.

(b) FPVAV Box Damper: The re-circulated air damper shall be open as the supply air damper closed.

3. SYSTEM START:

(a) System start is determined by the start of the air handling system serving the FPVAV box.

(b) FPVAV Box Fan: Shall start prior to the supply fan serving the area.

(c) FPVAV Box Damper: The re-circulated air damper shall modulate closed as the supply air damper modulates open.

4. SYSTEM RUN:

(a) System mode is determined by the status of the air handling system serving the FPVAV box.

(b) Unoccupied Heating Mode:

(1) FPVAV Box Fan: On if the space temperature falls below the unoccupied setpoint of 62F and remain on until the space temperature exceeds the unoccupied setpoint or for a period of 15 minutes, whichever is greater.

(2) FPVAV Box Damper: The re-circulated air damper shall be full open and the supply air damper shall be full closed.

(c) Unoccupied Cooling Mode:

(1) FPVAV Box Fan: On.

(2) FPVAV Box Damper: Modulate to maintain the unoccupied cooling CFM setpoint.

(d) Warm-up Mode:

(1) FPVAV Box Fan: On.

(2) FPVAV Box Damper: Modulate to maintain the warm-up CFM setpoint.

(e) Cool-down Mode:

(1) FPVAV Box Fan: On.

(2) FPVAV Box Damper: Modulate to maintain the cool-down CFM setpoint.

(f) Occupied Mode:

(1) FPVAV Box Fan: On.

(2) FPVAV Box Damper: Modulate to maintain the occupied space temperature setpoint. Upon a rise in space temperature above setpoint, the DDC controller shall modulate the VAV box damper open from the minimum supply CFM setting to the maximum supply CFM setting as necessary to maintain the space temperature at setpoint.

(g) Occupied Override Mode:

(1) The FPVAV box controller shall be programmed for occupancy override. By depressing the occupancy override button located on the space temperature sensor or via a BMS system override, the FPVAV box shall restore to the "Occupied Mode" condition.

5. SYSTEM STOP:

(a) FPVAV Box Fan: Off

(b) FPVAV Box Damper: Shall be indexed to the "System Off" condition.

6. SAFETIES AND ALARMS:

(a) Annunciate space temperature alarms to the BMS if the high or low analog limits are exceeded.

(b) Annunciate CFM alarms to the BMS if the high and low analog limits are exceeded.

(c) Emergency Shutdown:

(1) When the primary air handling unit serving the associated FPVAV receives an input from the fire alarm system, all FPVAV fans shall be de-energized and all FPVAV primary air dampers shall close. Shutdown shall be performed on a floor by floor basis based on inputs from the FAS.

(2) During smoke purge the primary air damper shall be open and the return air damper shall be closed.

7. FAILURE MODES:

(a) Fan Failure: If the fan serving the FPVAV box fails to operate, the FPVAV box damper shall be indexed to it's "System Off" condition.

(b) Sensor Failure: Upon the failure of an analog sensor, the FPVAV box damper shall remain in its last position and an alarm shall be annunciated to the BMS.

(c) Power Failure:

(1) FPVAV Box Damper: Upon a power failure shall remain in its last position.

1.9 MISCELLANEOUS SYSTEM CONTROL SEQUENCES

A. ENERGY METERING

1. Hot And Chilled Water Metering

(a) The hot and chilled water BTU usage shall be monitored, trended and reported.

(b) The actual daily, weekly, monthly, and annual BTU usage shall be monitored and trended and the associated reports generated on a monthly basis. The report shall be Excel spreadsheet based.

(c) Submit report format for approval.

B. WATER TREATMENT SYSTEM

1. The Mechanical contractor shall provide and install the water treatment system. This contractor shall provide all power and control wiring necessary for a completely operational system.

2. The BMS contractor shall furnish and wire the solenoid valve for blow down and the water meter for make-up lines.

3. The BMS shall monitor the common alarm and conductivity level for each system.

C. HOT WATER UNIT HEATER

1. Hot Water Unit Heater Not Monitored by BMS

(a) The BMS contractor shall furnish, install, and wire a space thermostat to control the unit heater. On a fall in space temperature below setpoint, the thermostat shall energize the unit fan. On a rise in space temperature, the fan shall be de-energized.

(b) For a hot water unit heater, a pipe-mounted electric aquastat shall lock out the fan if hot water is not available.

2. Steam, Electric, or Hot Water Unit Heater Monitored by BMS

(a) Alarm

(1) An alarm shall be annunciated on the BMS if the space temperature exceeds the high or low alarm limits.

(b) The BMS contractor shall furnish, install, and wire a space temperature sensor to control the unit heater fan. On a fall in space temperature below the setpoint of 60F (adj), the DDC controller shall energize the unit fan. On a rise in space temperature, the fan shall be de-energized.

(c) If steam or hot water unit heater, a hard-wired, pipe-mounted electric aquastat shall lock out the fan if hot water is not available.

(d) The space temperature sensor and fan status shall be a BMS input. The fan control shall be a BMS output. Fan status shall be monitored via a current sensing relay.

D. HOT WATER CABINET UNIT HEATER

1. Hot Water Cabinet Unit Heater Not Monitored by the BMS

(a) The BMS contractor shall furnish, install, and wire a thermostat and control valve to control the unit heater. On a fall in space temperature below setpoint, the thermostat shall open the valve and energize the unit fan. On a rise in space temperature, the fan shall be de-energized and the valve shall close.

(b) For a hot water cabinet unit heater, a pipe-mounted electric aquastat shall lock out the fan and lock the valve closed if hot water is not available.

2. Hot Water Cabinet Unit Heater Monitored by the BMS

(a) Alarm

(1) An alarm shall be annunciated on the BMS if the space temperature exceeds the high or low alarm limits.

(b) The BMS contractor shall furnish, install, and wire a space temperature sensor to control the hot water valve and fan. On a fall in space temperature below setpoint, the DDC controller shall open the valve and energize the unit fan. On a rise in space temperature, the fan shall be de-energized and the valve shall close.

(c) The space temperature sensor and fan status shall be a BMS input. The fan and heating valve control shall be a BMS output. Fan status shall be monitored via a current sensing relay.

(d) If steam or hot water cabinet unit heater, a hard-wired, pipe-mounted electric aquastat shall lock out the fan if hot water is not available.

E. EQUIPMENT RESTART PROGRAM

1. Subsequent to any building wide equipment shutdown, due to power failure, smoke control, occupancy scheduling, priority lead shedding, etc., the mechanical equipment (with the exclusion of those supplied with emergency power) restarts shall be staggered and phased to minimize peak electrical loads. Time delays shall be adjustable and shall be provided for each controlled motor. The final restart sequence shall be submitted for approval.

2. All units shall be remotely reset and restarted from the BMS after a safety shutdown.

F. EXPANSION TANKS

1. Operation

(a) Install and wire all devices necessary for expansion tank level controls including devices furnished by the expansion tank manufacturer. Furnish, install, and wire any devices not furnished by the expansion tank manufacturer which are necessary for a completely operational system.

(b) Provide high pressure (80 psi) compressed air schrader valve connection with a hand and check valve, within 10 feet of expansion tanks requiring air charging.

G. AIR FILTER (CARBON, HEPA, BOX, BAG TYPES)

1. The BMS system shall monitor the actual differential pressure across each filter. An alarm shall be generated if the differential pressure exceeds design conditions.

H. HEAT TRACE

1. The BMS shall monitor a common alarm contact from each heat trace control panel.

2. The BMS shall override the heat trace system on and sound an alarm if outside air temperature falls below 40°F and the heat trace system has not activated.

I. DOMESTIC HOT WATER HEATERS

1. The BMS contractor shall install and wire all devices supplied by the domestic hot water heater manufacturer. The BMS contractor shall furnish, install, and wire any devices not furnished by the domestic hot water heater manufacturer that are necessary for a completely operational domestic hot water heating system

2. The BMS shall monitor common alarm and supply water temperature. If an abnormal condition exists, an alarm shall sound at the BMS

J. FUEL OIL SYSTEM (ASSOC – EMERGENCY GENERATOR & TRANSFER SWITCHES)

1. Install and wire all fuel oil level-sensing equipment for fuel oil tanks. Install and wire all fuel oil leak-sensing equipment for tanks and containment piping. Fuel oil leak and level panels shall be installed in the fuel oil pump areas.

2. Provide remote tank level (gallons) readout panels for the fuel oil tank **[add location].** Provide all fuel oil pump status lights on each panel. The panel shall operate whether the BMS is operational or not.

3. Furnish and install hardwire interlock between the generator start and generator fuel oil pump start.

4. Provide and install fuel oil tank level sensors in fuel oil storage tank. Monitor level and actual fuel stored (in gallons). Provide all power and control wiring as required.

5. Provide and install fuel oil tank overfill alarm at tank. Provide all power and control wiring as required.

6. Provide and install fuel oil tank overfill alarm light and horn at tank fill connection on loading dock. Strobe light shall be activated whenever tank level exceeds 95% of capacity. Alarm horn shall be activated whenever tank level exceeds 99% of capacity. Provide key operated silence switch and key operated alarm light disable switch at tank fill connection.

7. Provide one DDC controller for each system.

K. EMERGENCY GENERATOR (ASSOC – FUEL OIL SYSTEM AND TRANSFER SWITCHES)

1. Enabled Mode

(a) Whenever the emergency generator is energized, its bypass damper shall open and the fuel oil control system shall be enabled. When the generator is de-energized, the bypass damper shall close and the fuel oil control system shall be disabled.

(b) The BMS contractor shall install a hardwired and/or pneumatic interlock between the associated ventilation damper sections and each generator. Damper operators and fan lines shall be sized to provide a maximum open/close time of 10 seconds. If pneumatics are utilized, dampers shall be piped in _" copper (minimum) to ensure full open dampers within 10 seconds. EP solenoids with _" orifice shall be located at damper. Outside air and spill dampers shall fail open on a loss of power or compressed air.

(c) A space thermostat shall modulate the bypass, spill and outside dampers to maintain its setting of 85 F. As the space temperature rises, the bypass damper shall gradually close and the outside and spill damper shall gradually open. On a decrease in temperature the reverse shall occur.

(d) Whenever the emergency generator is energized, all associated booster fan dampers, smoke dampers and/or fire/smoke dampers shall open. After the dampers are open, the associated emergency generator booster fan shall be energized. If the booster fan is greater than 2000 CFM, the fan shall not be energized until individual endswitches indicate that all associated dampers are open. When the emergency generator is de-energized, the booster fan shall continue to run until the emergency generator space temperature falls below 95F (adj.). When space temperature falls below the space temperature setpoint, the booster fan shall be de-energized and all associated dampers shall close.

(e) Each generator shall have its own individual damper sections.

(f) Provide one DDC controller for each emergency generator.

L. AUTOMATIC TRANSFER SWITCHES (ASSOC – FUEL OIL SYSTEM & EMERGENCY GENERATOR).

1. The BMS shall monitor the following points for each automatic transfer switch. Refer to electrical drawings for quantity and location.

(a) Connected to normal.

(b) Connected to emergency.

(c) Normal source available.

(d) Emergency source available.

(e) Automatic transfer switch in load shed.

M. SYSTEM INTEGRATION

1. General

(a) Furnish, install, and wire a communications interface between the BMS and the system to be integrated. Furnish, install, and wire all components necessary for a fully operational system interface.

(b) Data transfer rate shall be sufficient to maintain data as current to within 15 seconds.

(c) Provide one graphic page per floor for each foreign system.

(d) The integration modules shall be coordinated, installed and started up prior to the start up and check out of the foreign system. All data shall be checked for accuracy on both “sides” of the serial interface during the foreign system commissioning process. Provide all labor as required.

2. Chiller

(a) Furnish, install, and wire a communications interface between the BMS and the chiller control system. The BMS manufacturer shall be responsible for providing all hardware needed for a completely operational interface. This includes any hardware manufactured by the chiller manufacturer which is necessary for a completely operational interface.

(b) Provide two way serial communication hardware and software to interface with chiller control system to monitor and reset all chiller units.

3. Fire Alarm System

4. Lighting Control System

5. Security System

N. PRIORITY LOAD SCHEDULING SYSTEM

O. VARIABLE FREQUENCY DRIVE (VFD)

1. Control each variable speed drive as specified.

2. Monitor RPM, fault alarm, common alarm, bypass status, and KW of each VFD.

3. Provide start contact and speed set point to each VFD.

4. Variable frequency drives shall start unloaded and slowly ramp up to speed as required.

5. The DDC controllers shall calculate flow (air or water) rate based on RPM, equipment operating curves and actual balancing data where no air flow measuring stations or water flow meters are specified.

P. PAGING SOFTWARE

1. Pager interface software utilized to page building operators and maintenance personnel when user specified alarms occur.

Q. ELEVATOR CONTROL AND COMPUTER ROOM AIR CONDITIONING UNIT

1. GENERAL:

(a) Service:

(b) CAC units shall run and operate under unit mounted controls with remote setpoint reset and automatic restart from the BMS.

(c) Each CAC unit shall be furnished with the unit manufacturer's factory mounted and wired microprocessor controller. Each CAC unit mounted controller shall be wired, by the BMS contractor, to centrally located communications interface devices that will be furnished with the CAC units.

(d) The BMS contractor shall provide an interface to connect into the communications interface via open protocol standards (i.e. Modbus or BACnet) for control and monitoring of the CAC units.

2. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) High Static: A high discharge pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their "System Off" conditions. The fans shall remain off until the pressure switch is manually reset.

(c) Low Suction: Low suction pressure switches shall stop the supply and return fans when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their "System Off" conditions. The fans shall remain off until the pressure switch is manually reset.

(d) Filter Condition: Monitor differential pressures across filters and annunciate alarm when differential pressure set points are exceeded.

(e) Water Leak Detection: A water leak detector, installed as per the Water Leak Detection specification section, shall stop the supply fan and annunciate an alarm whenever a water leak is detected. The fan shall remain off until the switch is reset.

(f) Emergency Shutdown:

(1) Duct smoke detector shall stop the fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detectors shall be wired into the building fire alarm system.

(2) The fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers and control valves shall be indexed to their “System Off” conditions.

3. FAILURE MODES:

(a) Fan Failure: If the fan fails to operate, an alarm shall be annunciated and dampers and control valves shall be indexed to their “System Off” conditions.

(b) Sensor Failure: Upon the failure of an analog sensor, associated dampers and control valves shall remain at their last position and alarm shall be annunciated.

(c) Wall mounted room sensor shall monitor room temperatures for CAC-23 to CAC-31. Should room temperature exceed set point, an alarm shall be sounded, the unit shall shut down, and the emergency dampers shall close to the unit and open to the floor supply dectwork.

(d) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

1.10 SPECIAL DESIGN CONSIDERATIONS

A. LABORATORY

1. FUME HOOD CONSTANT VOLUME MONITOR

(a) The Constant Volume Monitor shall be applicable to the following fume hood exhaust configurations:

(1) Manifolded exhaust system.

(2) Individual exhaust system at each hood.

(b) The fume hood control system shall be applicable to the following fume hood sash configurations:

(1) Single vertical sash (e.g., bench hood).

(2) Two side-by-side vertical sashes (e.g., bench hood).

(3) Two overlapping vertical sashes (e.g., distillation or walk-in hood).

(4) Four sashes as two sets, side-by-side, of two overlapping sashes (e.g., walk-in hood).

(5) Two, three or four horizontal sashes sliding in one or two tracks (e.g., bench, walk-in).

(6) Combination sash consisting of one vertical sash segment containing two, three or four horizontal sashes sliding in one or two tracks (e.g., bench).

(c) Provide for each fume hood a separate fume hood monitor with the following capabilities:

(1) The fume hood monitor shall be stand-alone and microprocessor based. The monitor shall have integral sensors (e.g., temperature compensation and airflow).

(2) Fume hood monitors shall have the capability of being networked to the building control system without the use of gateways, and all data must be available to designated operator terminals and PC workstations. The fume hood monitor shall be capable of operating in occupied and unoccupied modes with user definable setpoints for each mode. The switching of occupied and unoccupied modes shall be accomplished via the network or a local switch.

(3) Fume hood monitor shall include user definable push buttons.

(4) All data in the fume hood monitor shall be maintained in non-volatile EEPROM type of memory. Momentary or extended losses of power shall not change or affect any of the monitor's setpoints, calibration settings, or emergency mode programming.

(5) The fume hood monitor shall interface to the BMS.

(6) The fume hood monitor shall measure and indicate average face velocity at all times. The fume hood monitor must be field-calibratable with password-protected software to prevent tampering. Alarm setpoint shall be capable of being changed by lab safety personnel using the Portable Operator's Terminal (POT) connected to the fume hood monitor. The fume hood monitor shall have selectable digital indication of average face velocity (FPM, MPS or no indication).

(7) Each fume hood monitor shall have spare input and output points for connection to external devices. External devices are defined as motion sensors, external horns, room lights, external hardwired alarm panels, photocells, etc.

(8) The fume hood monitor shall comply with the following agency listings:

(i) UP 916, PAZX (Energy Management)

(ii) UP 864, UUKL (Smoke Control)

(iii) UP 864, UDTZ (Signal Management)

(iv) UP 916, QUAY (Process Management)

(9) To increase safety for individual fume hood operators: If the sash is raised above the safe operating height for a user-programmable time period, the monitor will have the capability of sounding an audible alarm for two seconds every 58 seconds.

(10) Calibration of the air velocity sensor of the fume hood monitor shall require a minimum of three (3) calibration points to ensure accurate measurement at all possible sash positions/heights and over the expected range of airflow. Monitors that use only one (1) or two (2) calibration points or monitors that cannot be field programmable are unacceptable

(11) Indicator lights green and red (normal, alarm). The GREEN light shall indicate normal condition. RED will indicate a programmable alarm condition. In alarm (RED), an audible horn will initiate. The horn shall be turned off as the RED light is turned off. The indicator lights/horn sequence is intended to be the hood user's primary indication of safe operation. The face velocity high/low alarm limits, and time delays shall be capable of being set by safety personnel based on the type of chemicals being used in and the performance characteristics of each hood.

(12) Alphanumeric display of the type of alarm/emergency condition, indicating "LOW face velocity" or "HIGH face velocity" and "EMERGENCY" when the emergency button has been pushed. A diagnostic message shall be provided to notify hood operator of flow sensor failure.

(13) An "emergency" button. When pressed, the controller shall respond immediately by turning on the RED alarm light and horn.

(14) Horn silence button. When pressed while the horn is sounding, it shall turn the horn off.

(15) A terminal jack for connection to the portable operator's terminal to monitor/edit all points internal to the fume hood monitor. As a minimum, the following points must be available to be programmed and adjustable from the terminal jack: Face velocity, low alarm, high alarm, emergency alarm, occupied/unoccupied, 2 auxiliary input buttons, field calibration, display averaging, engineering units, general failure, high alarm limit, low alarm limit, display on/off, and display resolution.

1.11 FIRE AND SMOKE CONTROL SEQUENCES

A. Smoke Detection Interlock

1. Floor Damper Initiated Smoke Control

(a) When the smoke detector on any floor detects smoke, the following shall occur:

(1) The main supply and return fans shall continue to run;

(2) The main fan system return air damper(s) shall close;

(3) The outside air damper(s) shall open;

(4) The exhaust smoke damper on the smoke floor shall open;

(5) All other exhaust damper(s) shall close;

(6) Supply smoke damper(s) on floor above and floor below shall open;

(7) All other supply smoke damper(s) shall close; and

(8) All CAV or VAV supply boxes shall open to full open position.

2. Main Fan Initiated Smoke Control

(a) If smoke detectors at the main fans indicate smoke (which is unlikely since floor return should read smoke first), the return air damper will close, the outside air damper will open, the freezestats will by bypassed, the fans will continue to run on 100% makeup and 100% spill. All floor dampers will remain open. If floor return subsequently reads smoke, the above sequence of floor damper initiated smoke control will be initiated.

3. If smoke is detected during unoccupied cycle with fans off the above sequence will be activated and fans shall be started automatically.

B. Manual Smoke Purge Override – Panel Located in the Fire Command Center:

1. Provide manual means at fire command station, or at location required by code, to start and stop return fan and/or supply fan to achieve 100% exhaust and/or 100% make-up. In this cycle, the supply fan discharge air damper must be wide open, as sensed by an end switch, before the supply fan starts.

2. The BMS Fire Control Panel by BMS contractor shall be provided with on/off/auto toggle switches for over riding control of main HVAC system return/exhaust fans, network and electrical room fans, and tug tunnel fans. The switches shall override normal BMS operations as required by the Fire Department. For each mechanical fan, provide a relay energized by the BMS fire panel. Refer to the electrical drawings to determine the location of the panel. When energized, the relay will open the respective associated F/S and exhaust dampers and close the respective return air damper associated with the return fan. A “smoke” position will permit manual start of return air fan. The freezestat and emergency shutdown shall be overridden. For systems with variable volume return fans, VFD shall be set to minimum when return fan starts. Provide a manual gradual switch near the return fan restart switch to permit control of VFD on return fan. A firestat at inlet to return fan will be provided to act as override, on manual operation of return air fan, to stop fan if temperature exceeds 125°F. Provide two single pole double throw end switches on exhaust damper and on intake damper to prevent respective fan start when dampers are indexed to 100% exhaust on supply positions.

3. Fire Alarm Panel Shutdown of Exhaust Fans
   (a) Upon a signal from the fire alarm panel (by and coordinatd with electrical contractor), all exhaust fans shall shut down. BMS contractor shall coordinate all exhaust fan wiring and/or controls with the fire alarm panel contractor.

C. Electric/Communications Rooms

1. When a fire alarm on the floor is activated, the smoke damper to each electric/communications room shall be closed by the fire alarm system (FAS). When smoke exhaust is required, the FAS shall reopen the dampers, open the floor general exhaust and smoke exhaust dampers and start the smoke exhaust fan. Provide interconnecting wiring and/or tubing, EP relays, etc. as required.

D. Return Fan Used For Smoke Exhaust

1. Fans with smoke detectors shall stop upon the presence of smoke through the FAS system (except in smoke exhaust mode).
2. The fire alarm system shall start the return fan in smoke mode whenever smoke exhaust is required. All interlocked dampers shall open and close with fan operation. Common dampers shall open as required to allow exhaust airflow during smoke exhaust mode. Air handling unit return air dampers shall remain closed and exhaust/relief dampers shall remain open during smoke exhaust.

PART 2 - PRODUCTS

(Not Applicable)

PART 3 - EXECUTION

(Not Applicable)

END OF SECTION 15951

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Testing, adjusting, and balancing of Air Systems.

B. Testing, adjusting, and balancing of Hydronic and Steam Systems.

C. Measurement of final operating conditions of HVAC Systems.

D. Sound measurement of equipment operating conditions.

E. Vibration measurement of equipment operating conditions.

F. Measurement of the IAQ after the completion of the final balancing.

1.2 SCOPE OF WORK:

A. General:

1. Testing, adjust and confirm design airflows rates, pressure drops, pressures, temperatures and heat transfer performance for HVAC systems, including, but not limited to chilled water system, condenser water system, steam and condensate system, hot water heating system, supply air, return air and exhaust air systems, including all associated pumps, heat exchangers, coils, fans, dampers, diffusers, terminal devices, fume hoods, valves and accessories, cooling towers, boilers, chillers, etc.

2. Provide all necessary labor, materials, products, equipment and services to balance and test all HVAC systems, to verify conformance to specified quantities, and to the design intent of the mechanical system and for the testing of all the fire safety systems.

3. Cooperate with all other trades, including, but not limited to, building controls, fire alarm, sheetmetal and piping sub-contractors to ensure the Work is carried out without interference to other Work.

4. Provide openings required for pitot tube traverses. After balancing, close openings with removable gasketed plugs. Submit samples of proposed plugs for approval.

5. Conduct routine inspections during the mechanical systems installation and report on poor ductwork installation (likely to produce abnormal leakage), poor piping installation, poor placement of dampers or valves, and any circumstance which will encumber the balancing of the mechanical systems.

6. Review Drawings and Specifications and ensure that adequate provisions

are made in the mechanical installation to facilitate the balancing of all air, steam and water systems; make recommendations to the Architect/Engineer where additional measures may be required.

7. Include all items of labor, materials, products, equipment and devices required to comply with such standards and codes in accordance with the contract documents to balance all air and hydronic systems, to verify conformance to specified quantities and to the design intent of the mechanical system. Where quantities, sizes or other requirements indicated on the drawings or herein specified are in excess of the standard or code requirements, the specifications and drawings shall govern.

1.3 RELATED DOCUMENTS

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

B. This section is a part of each Division 15000 Section making reference to Testing, Balancing and Adjusting and the other sections of Division 15.

1.4 REFERENCES:

A. ASHRAE - Standard 111 - 1988 Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air Conditioning, and Refrigeration Systems.

B. ASHRAE - 1987 HVAC Systems and Applications Handbook: Chapter 57, Testing, Adjusting and Balancing.

C. AABC- National Standards for Total System Balance.

D. NEBB - Procedural Standards for Testing, Balancing and Adjusting of Environmental System.

E. SMACNA - HVAC System Testing, Adjusting and Balancing.

F. Sheet Metal Industry - Certification of Testing, Adjusting and Balancing Technicians.

1.5 DEFINITIONS

A. Systems testing, adjusting, and balancing is the process of checking and adjusting all the building environmental systems to produce the design objectives. It includes:

1. the balance of air, steam and hydronic distribution;

2. adjustment of total system to provide design quantities;
verification of performance of all equipment and automatic controls;

3. sound and vibration measurement.

4. IAQ measurements

B. Test: To determine quantitative performance of equipment.

C. Adjust: To regulate the specified fluid flow rate and air patterns at the terminal equipment (e.g., reduce fan speed, throttling).

D. Balance: To proportion flows within the distribution system (submains, branches, and terminals) according to specified design quantities.

E. Procedure: Standardized approach and execution of sequence of work operations to yield reproducible results.

F. Report forms: Test data sheets arranged for collecting test data in logical order for submission and review. These data should also form the permanent record to be used as the basis for required future testing, adjusting, and balancing.

G. Terminal: The point where the controlled fluid enters or leaves the distribution system. These are supply inlets on water terminals, supply outlets on air terminals, return outlets on water terminals, and exhaust or return inlets on air terminals such as registers, grilles, diffusers, louvers, and hoods.

H. Main: Duct or pipe containing the system's major or entire fluid flow.

I. Submain: Duct or pipe containing part of the systems' capacity and serving two or more branch mains.

J. Branch main: Duct or pipe serving two or more terminals.

K. Branch: Duct or pipe serving a single terminal.

1.6 SUBMITTALS:

A. Procedures: Furnish submittals in accordance with the general requirements of the Contract Documents.

B. Bid Submittals: Submit with bid, proposed balancing procedure on a system by system basis.

C. Activity Programs: The Air and Water Balance contractor shall prepare and submit for approval a detailed activity program. The program shall be in accordance with the overall Construction Schedule.

1. Specific requirements included within the activity program shall be:

   (a) Required dates for the acceptance of system/equipment from the installing contractor "ready for balance".

   (b) Required Periods for the individual system balancing.

   (c) Requirements for attendance from the installing contractor and their suppliers.

2. Activity Programs shall be prepared for each major system and/or specific item of equipment.

3. Activity Programs shall include, but shall not be limited to the following:

   (a) Heating Water Piping System including:

      (1) Pumps

      (2) Boilers and/or heat exchangers

      (3) AC units - heating coils

      (4) Perimeter radiation

   (b) Chilled Water Piping System including:

      (1) Pumps

      (2) Chillers

      (3) Air Handling Units - Cooling Coils

   (c) Individual Air Handling Units including:

      (1) Fans (Supply, Return/Exhaust)

      (2) Coils (Cooling, heating and snow melting)

      (3) Outside air, return air and spill air dampers

      (4) Air Distribution Systems

   (d) Tug Tunnel Ventilation Systems

   (e) General Exhaust System

   (f) Specialized Ventilating Systems:

      (1) Elevator equipment rooms

      (2) Electric rooms

      (3) Computer Rooms

      (4) Supplementary AC Systems

   (g) Toilet Exhaust System

   (h) Steam Humidification System

   (i) All other air handling and exhaust systems as indicated on the drawings

D. Progress Reports: Submit progress reports on a system by system basis, including preliminary recommendations; allow for one such progress report, per system, prior to issue of final report. Progress report shall be issued upon notification by the Architect/Engineer shall be turned around within 10 working days.

E. Certified Test Reports: Furnish test results and a schematic layout for each system, certified by the Contractor. Six completed copies including schematic layouts, shall be submitted to the Owner. Balancing report submitted shall list each VAV/ CV box, grille, register and diffuser associated with each system, giving numerical identification (including room number or area name), design quantity, final quantity, etc., and design power requirements for all supply and exhaust fans and actual operating conditions listing RPM, volts, amps, kw, etc., in accordance with AABC/NEBB test report forms. Include identification and types of instruments used and their most recent calibration date with test reports.

1. General

(a) Provide a complete balancing report in 3-ring binder manuals. Report should include contents, page and index tabs and cover identification at front and side.

(b) Include types, serial number and dates of calibration of test instruments. (Submit calibration certificates).

(c) Record test data on a sepia made from the latest available revised set of mechanical drawings and submit six (6) copies upon completion of the balancing contract.

(d) Install at each piece of mechanical equipment a "Data Register" showing significant operating temperatures, pressures, amperes, voltage frequency, motor KW, FLA, belt size/model number and sheave size. "Data Register" to be enclosed in a plastic holder securely attached to the equipment or to a wall in the adjacent area.

(e) Submit with report, fan and pump curves with operating conditions plotted. Submit grille and diffuser shop drawings and diffusion factors.

(f) Submit with the report schematics of all the air and water systems. The schematics should include the following:

F. Report Data

1. Duct Air Quantities - Mains, Branches, Outside Air, Return Air and Exhausts (Maximum and Minimum):

(a) Duct sizes (clear inside dimension)

(b) Number of pressure readings

(c) Sum of velocity

(d) Average velocity

(e) Duct recorded air flow rate

(f) Duct design air flow rate

(g) Provide data with system schematic

2. Air Inlet and Outlets:

(a) Outlet identification location and designation

(b) Manufacturer's catalogue identification and type

(c) Application factors

(d) Design and recorded velocities

(e) Design and recorded air flow rates

(f) Deflector vane of diffuser cone settings

(g) Provide data with system schematic

(h) Static Pressure upstream of terminal device.

3. Building Pressurization Data:

(a) Outside air temperatures

(b) Outside wind velocity

(c) Building pressures plotted with respect to systems
(d) Supply air, return and exhaust air flow rates

(e) Locations of pressure measuring points, inside and outside building

4. Pumps

(a) Installation Data:

(b) Design Data:

(c) Recorded Data:

5. Expansion Tank Data:

(a) Manufacturer, size, capacity and type

(b) Pressure reducing valve setting

(c) Pressure relief valve setting

(d) Expansion tank pressure reading

6. Air Heating and Cooling Equipment

   (a) Equipment Installation Data:

   (b) Equipment Design Data:

   (c) Equipment Recorded Data:
      (1) Element type and identification (location and designation)

      (2) Entering and leaving water temperatures

      (3) Entering steam pressure

      (4) Water pressure drop across HX

      (5) Water pressure drop across control valves

      (6) Steam pressure drop across control valves

      (7) Adjusted temperature rise or drop

7. Emergency Generator Ventilation
   (a) Generator manufacturer, model and Capacity

   (b) Design air flow at 100% outside air

   (c) Measured air flow at 100% outside air

   (d) Air temperature of inlet Louver

   (e) Air temperature at exhaust Louver

   (f) Room air temperature

8. Notice: Furnish written notification to the Owner's representatives 5 days prior to commencement of the work.

1.7 QUALITY ASSURANCE

A. Testing and Balancing Agency Qualifications:

1. Employ the services of an independent testing, adjusting, and balancing agency meeting the qualifications specified below, to be the single source of responsibility to test, adjust, and balance the building mechanical systems identified above, to produce the design objectives. Services shall include checking installations for conformity to design, measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results.

2. The independent testing, adjusting, and balancing agency shall be certified by the National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC) in those testing and balancing disciplines required for this project, and having at least one Professional Engineer registered in the State in which the services are to be performed, certified by NEBB or AABC as a Test and Balance Engineer.

3. The air and water balance agency shall provide proof of having at least 5 years testing, adjusting and balancing experience, as well as having successfully completed at least five projects of similar size and scope.

4. The work must be performed by a Certified Testing, Adjusting and Balancing Technician who may be assisted by other TAB Technicians. The Certified Testing, Adjusting and Balancing Technician is responsible for:

    (a) Procedures to be followed

    (b) Accuracy of all testing

    (c) Integrity of recorded data

    (d) Entering all data and reporting any abnormal or notable conditions on the report forms

    (e) Initialing and dating each sheet

5. The General Section of the Balance Report shall include the names, signatures, and registration numbers of the Technicians who were assigned to the project.

6. Codes and Standards:

    (a) NEBB: "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

    (b) AABC: "National Standards For Total System Balance".

    (c) ASHRAE: ASHRAE Handbook, 1984 Systems Volume, Chapter 37, Testing, Adjusting, and Balancing.

7. Contractor's Quality Assurance Responsibilities: This Contractor is solely responsible for quality control of the Work. Comply with the general requirements of the contract.

B. IAQ Testing Agency Qualifications:

1. The testing and balancing agency shall employ the services of an independent IAQ testing agency to test the building air systems identified above, to produce an IAQ report.

2. In conjunction with the testing and balancing agency, the IAQ testing agency's services shall include checking installations for conformity to design, measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results.

3. The independent testing agency shall be certified by a National entity jurisdiction in IAQ testing disciplines required for this project, and having at least one Professional Engineer registered in the State in which the services are to be performed.

4. The testing agency shall provide proof of having at least 5 years testing experience, as well as having successfully completed at least five projects of similar size and scope.

5. The work must be performed by a Certified Technician who may be assisted by other Technicians. The Certified Technician is responsible for:

   (a) Procedures to followed

   (b) Accuracy of all testing

   (c) Integrity of recorded data

   (d) Entering all data and any abnormal or notable conditions in report forms

   (e) Initialing and dating each sheet

6. The General Section of the Report shall include the names, signatures, and registration numbers of the Technicians who were assigned to the project.

1.8 HVAC CONTRACTOR RESPONSIBILITIES

A. Prepare each system for testing and balancing

B. Cooperate with the testing agencies, provide access to all work, equipment and systems.

C. Put all heating, ventilating and air conditioning systems and equipment into full operation and shall continue the operation of same during each working day of testing and balancing. Operate systems and under conditions required for proper testing, adjusting, and balancing.

D. Notify Testing Agency's project manager, Owner and Engineer seven days prior to time system will be ready for testing, adjusting, and balancing. Project readiness shall include:

   1. Systems are started and running (fans and pumps have been checked for proper rotation).

   2. Permanent electrical power wiring is complete.

3. Verification that all ductwork is fabricated and installed as specified.

4. Ceilings are installed in critical areas where air pattern adjustment may be required. Access to balancing devices are provided.

5. All equipment and ductwork access doors are securely closed.

6. All balancing, smoke and fire/smoke dampers are installed and in full open positions.

7. All isolation and balancing valves are open and control valves are operational.

8. System installation is complete, with Controls and Instrumentation installed and fully operational.

E. Where fans (air handling units, supply fans, return fans, exhaust fans, etc.) are provided with variable pitch sheaves, HVAC Contractor shall adjust sheaves, as required, at no additional cost to the Owner, until desired Design Points (CFM and Static Pressure) are reached. If adjustment of the variable pitch sheaves is beyond the range of the sheaves, HVAC Contractor shall replace sheaves, as required, at no additional cost to the Owner, until the desired Design Points (CFM and Static Pressure) are reached. Where fans (air handling, supply, return, exhaust, etc.) Are specified with fixed ratio sheaves, HVAC Contractor shall replace sheaves with new sheaves, at no additional cost to the Owner until desired Design Points (CFM and Static Pressure) are reached. Where fans (air handling units, supply fans, return fans, exhaust fans, etc.) are of the vane axial type with adjustable vanes, HVAC Contractor shall, at no additional cost to Owner, adjust vanes as required until desired Design Points (CFM and/or Static Pressure) are reached.

F. All duct work etc. that is found to exceed the permissible leakage rates shall be immediately repaired by the HVAC contractor, at no additional cost and in a timely manner so as not to interfere with the progress of the work.

1.9 SEQUENCING AND SCHEDULING

A. Sequencing work to commence after completion of systems and schedule completion of work before Substantial Completion of Project.

1.10 DRAWING AND CONSTRUCTION REVIEW

A. Perform a preconstruction review of the following documents:

1. Updated construction drawings

2. Contract specifications

3. Addenda

4. Submittal data

5. Shop drawings

6. Automatic Control drawings

B. Prepare a report of the preconstruction review list of recommended changes to allow most effective balancing.

C. Perform four construction reviews of the mechanical installation during the progress of the project. Purpose of the reviews to be:

1. Identify potential problems for performing balancing.

2. Identify modifications which will aid balancing.

3. Schedule and coordinate balancing with other work and other trades.

D. Prepare a report of each construction review.

E. Pre-Balancing Conference: Prior to beginning of the testing, adjusting, and balancing procedures, schedule and conduct a conference with the Architect/Engineer and representatives of installers of the mechanical systems. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting, and balancing.

1.11 PROJECT/SITE CONDITIONS:

A. General: Do not proceed until systems requiring testing, adjusting and balancing are clean and free from debris, dirt, and discarded building materials.

B. Air balance and testing shall not begin until system has been completed and is in full working order. The mechanical contractor shall put all heating, ventilating and air conditioning systems and equipment into full operation and shall continue the operation of same during each working day of testing and balancing.

PART 2 - PRODUCTS

2.1 EQUIPMENT

A. Provide all necessary testing, retesting, and balancing equipment including but not limited to instruments, gauges, blowers, tools, scaffolding, ladders, etc.

B. Provide all necessary instruments. Instruments shall be used and applied which are best suited to the system function being tested. Instruments shall be in first class state of repair and have been calibrated within a period of six months prior to starting the job. Calibration history of each instrument shall be available for examination. Instruments shall be re-calibrated upon completion of the job if required by the Design Engineer to prove reliability

2.2 SOURCE QUALITY CONTROL:

A. Test, calibrate, retest and recalibrate measuring instruments at the laboratory.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before commencing work, verify that systems are complete and operable. Ensure the following:

1. Equipment is operable and in safe and normal condition.

2. Temperature control systems are installed complete and operable.

3. Proper thermal overload protection is in place for electrical equipment.

4. Pre and final filters are clean and in place. If required, install temporary media in addition to final filters.

5. Duct systems are clean of debris.

6. Correct fan rotation.

7. All fire, fire/smoke and volume dampers are in place and are in the full open position.

8. Coil fins have been cleaned and combed.

9. Access doors are installed and closed and duct end caps are in place.

10. Terminal devices and air outlets are installed, connected and accessible and adjusted for full maximum flow.

11. Duct system leakage has been minimized. All duct systems requiring Leakage Tests have been tested and accepted.

12. Proper strainer baskets are clean and in place.

13. Correct pump rotation.

14. Hydronic systems have been flushed, filled, and vented.

15. Service and balance valves are open.

B. Report to Architect/Engineer any defects or deficiencies noted during performance of services.

C. Promptly report abnormal conditions in mechanical systems or conditions which prevent system balance.

D. If, for design reasons, system cannot be properly balanced, report as observed.

E. Beginning of work means acceptance of existing conditions.

3.2 PREPARATION

A. Provide instruments required for testing adjusting and balancing operations. Make instruments available to Architect/Engineer to facilitate spot checks during testing.

3.3 INSTALLATION TOLERANCES

A. Adjust Air Handling Systems to the following tolerances:

1. Supply systems shall be balanced so that:

(a) The total quantity to each space is within - 5% to + 10% of design values.

(b) If two outlets in space, each outlet is within - 10% to +10% of design value.

(c) If three or more outlets in space, each outlet is within -15% to +15% of design value.

2. Exhaust and return systems shall be balanced so the total quantity from each space is -10% to +10% of design values.

B. Adjust Hydronic Systems to the following tolerances:

1. Heating System (See Plans):

(a) Supply water temperature 80°F to 120°F: 0% to +10% of design value.

(b) Supply water temperature 120°F to 160°F: -5% to +10% of design value.

(c) Supply water temperature above 160°F: -10% to +10% of design value.

2. Cooling System (See Plans:

(a) Supply water temperature above 55°F: 0% to +10% of design value.

(b) Supply water temperature 45°F to 55°F: -5% to +10% of design value.

(c) Supply water temperature below 45°F: -10% to +10% of design value.

3.4 ADJUSTING

A. Recorded data shall represent actually measured or observed condition.

B. Permanently marked settings of valves, dampers, and other adjustment devices, allowing settings to be restored. Set and lock memory stops.

C. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

D. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.5 WELDING INSPECTION:

A. Visual Inspection: Perform in accordance with Industry Standards. Cut out and test defective welds. If the percentage of defective welds is excessive, cut out and test additional welds as directed by Architect/Engineer.

3.6 VERIFICATION OF CONTROL OPERATION

A. General: Perform the checks outlined in the following for all air system controls:

1. Thermostats and humidistats - Verify calibration and operation of all thermostats and humidistats. Any Deficiencies shall be reported for correction. Recheck after correction. Record thermostat set point and output signal, space temperature.

2. Damper Operation - Verify operation and position for all dampers. Any Deficiencies shall be reported for correction. Recheck after correction.

3. Other Controls - Simulate control operations with control contractor in accordance with design requirements and manufacturer’s recommendations. Any deficiencies shall be reported for correction. Recheck after correction.

3.7 OPERATING TESTS

A. General: After the various systems are pressure-tested and cleaned as hereinbefore specified, each piping and air handling system shall be tested in the presence of the Owner and Owner's representatives. Five days advance written notice of the tests shall be given to the Owner by the Contractor who in turn will notify other parties interested. Furnish all gauges, instruments, test equipment and personnel required for the tests. Adjust all equipment to perform with the least possible noise and vibration consistent with its duty. Quietness of operation of all equipment is a requirement. Any equipment producing objectionable noise in occupied spaces must be repaired or removed and replaced with satisfactory equipment.

B. Piping Systems: operate the cooling systems, and make adjustments in controls and equipment, and complete necessary balancing to deliver not less than the water quantities shown on the drawings at each equipment item.

C. NC (Noise Criteria) Tests: Operate the air handling systems after balancing, to determine that the scheduled NC ratings in the spaces are not exceeded.

3.8 AIR, WATER AND STEAM BALANCING:

A. Performance Verification:

1. Within one year after completion of air and water balance work, the Owner may request recheck and verification of outlets, supply air fan, exhaust air fan, pump, and other equipment listed in test report. Provide technicians and instruments when making tests required during this period of time.

2. Put all heating, ventilating and air conditioning systems and equipment into full operation and continue operation during each working day of testing and balancing.

3. Perform all work necessary to complete testing and balancing of air and water systems, including but not limited to the following.

(a) Balance, adjust and test air-moving equipment and air distribution, supply, return, exhaust, spill and recirculation systems.

(b) Test condenser water pumps.

(c) Balance condenser water distribution system.

(d) Test chilled water pumps.

(e) Balance chilled water distribution system.

(f) Test hot water pumps.

(g) Balance hot water distribution system.

(h) Test the entering and leaving steam pressure -PRV's

(i) Test the entering steam pressures - Heating Coils

(j) Test the entering steam pressures - Humidifiers in air handling units.

(k) Submit for approval complete test and balance data upon completion of tests and balancing.

B. Balance Data Report Forms: Provide both design and actual conditions for each item listed. Reports are required for each air handling supply, exhaust/spill, and recirculation and water system. Include as a minimum the following data.

1. Supply Systems:

(a) Date

(b) System No. and location

(c) Fan model #, arrangement, class

(d) Fan motor RPM, pulley size

(e) Fan motor amperage

(f) Pressure drop across coils and filters (advise if coils are wet or dry)

(g) Fan suction static pressure

(h) Fan discharge (or plenum) static pressure

(i) Unit discharge static pressure (External)

(j) Compressor amperage

(k) Rated motor amperage, starter heater number and ampere rating

(l) Recirculated air flow (CFM)

(m) Outside air flow (CFM)

(n) Outside air conditions (DB and WB)

(o) Mixed air conditions (DB and WB)

(p) Return air conditions (DB and WB)
(q) Entering coil conditions (DB and WB)

(r) Leaving coil conditions (DB and WB)

(s) Fan discharge conditions (DB and WB)

(t) Main Supply duct (CFM and Static Pressure)

(u) Final adjusted percentage of design

2. Exhaust and Recirculation Systems:

(a) Date

(b) Fan model #, arrangement and class

(c) System number and location (corresponding supply fan system)

(d) Rooms or area served

(e) Fan motor RPM

(f) Motor amperage and starter heater number and amperage rating

(g) Rated motor amperage

(h) Fan inlet static pressure and temperature (DB & WB)

(i) Fan outlet static pressure and temperature (DB & WB)

(j) Final adjusted percentage of design

3. Room Data:

(a) Room number

(b) Supply and exhaust/return system number

(c) Supply at each diffuser (min. and max. for VAV systems)

(d) Return/Exhaust at each register or grille

(e) Air opening sizes and area factors

(f) Final adjusted percentages of each opening

4. Water Systems:

(a) Outdoor conditions at time of test (DB & WB)

(b) Pump name and number (mfg., model #, type)

(c) Pump RPM

(d) Pump amperage (individual operation)

(e) Pump amperage (multiple operation)

(f) Rated motor amperage, starter heater number and amperage rating.

(g) Pump inlet pressure (individual operation)

(h) Pump inlet pressure (multiple operation)

(i) Pump outlet pressure (individual operation)

(j) Pump outlet pressure (multiple operation)

(k) Flow (individual operations)

(l) Flow (multiple operations)

(m) Supply temperature

(n) Return temperature

(o) Flow at each heat exchanger (GPM, EWT, LWT and pressure drops)

(p) Flow at each air conditioning unit

(q) Flow at each flow measuring station

(r) Inlet and outlet temperature at each air conditioning units' coils (water conditions shall be recorded at same time as air temperature)

(s) Inlet and outlet pressure at each air conditioning unit

(t) Final adjusted percentage of design

5. Steam Systems:

(a) Outdoor conditions at time of test.

(b) PRV inlet and outlet pressures

(c) Heating Coils inlet pressures

(d) Humidifiers inlet pressures

C. Balancing Procedure:

1. Air Distribution Systems: Operate the air handling systems and make adjustments in the controls and equipment as required to balance the systems to deliver the required design air quantities and temperatures.

(a) Air Handling Systems:
(1) First set of air filters shall be in place whenever fans are run. Replace with clean set of specified filters before testing.

(2) Run supply fan with all dampers in their normal position (minimum outside air). Duplicate normal conditions as far as possible with clean filters in place, coils in operation, etc. Adjust for proper ratio of outside and return air.

(b) Note that VAV boxes are calibrated at factory. Nevertheless, recalibrate each VAV box in field as part of this work. Air balancer shall show two readings for each box, minimum and maximum and corresponding inlet and outlet static pressure.

(c) Note that fan powered mixing boxes are calibrated at factory. However, due to changing inlet conditions, recalibrate each mixing box in field as part of this work and provide reading for box (CFM) (M^3/sec), and primary air at maximum and minimum setting and corresponding inlet and outlet static pressure.

(d) NC (Noise Criteria) Tests: Operate the air handling systems after balancing, to determine that the schedule NC ratings in the spaces are not exceeded.

NOTE: All volume dampers and VAV boxes shall be positioned for maximum air flow before taking initial supply airflow and static pressure readings. Advise Engineer immediately if design airflows of air handling units are not achieved before proceeding with further testing.

(e) Test and adjust fan RPM to design requirements.

(f) Test and record motor load in amperages at various filter percentages.

(g) Make pitot tube transverse of main supply ducts. Obtain design air flow at 50 percent dirty filter condition.

(h) Test and adjust systems for design recirculated air flow .

(i) Test and record system static pressures suction and discharge.

(j) Test and adjust systems for design outside air.

(k) Test and record entering air temperatures (DB & WB).

(l) Test and record leaving air temperatures (DB & WB).

(m) Adjust main supply and return air ducts to proper design air flow.

(n) Test and adjust each diffuser, grille and register to within percentage of design requirements as detailed above.

(o) Adjust all zones to proper design CFM, supply and return. VAV devices (boxes) shall be tested for minimum and maximum flow.

(p) Identify each VAV terminal device, grille, diffuser and register as to locations and area.

(q) Size, type, factors, and manufacture of diffusers, grilles, registers, and tested equipment shall be identified and listed. Use Manufacturer's ratings on equipment to make required calculations.

(r) Readings and tests of diffusers, grilles, and registers shall include required velocity and test resultant velocity, required air flow and test resultant air flow after adjustments.

(s) Set and adjust automatically operated dampers to operate as specified, indicated, and/or noted. Check controls for proper calibration and list controls requiring adjustment.

(t) Adjust diffusers, grilles, and registers to minimize drafts.

(u) Test filter manometer and set tap at maximum pressure drop.

2. AC Units

(a) During balancing of the AC units ensure that outdoor air, general exhaust and toilet exhaust systems are operating at their design levels.

(b) Adjustment and balancing of the AC units will require close coordination with the mechanical and building controls contractors to ensure desired operation sequence and performance are achieved.

(c) Some of the AC units have been provided with variable frequency inverter drives, which should facilitate the balancing operation.

(d) Test and adjust fan RPM to design requirements. Ensure that design volume flow rates and static pressure are achieved at branch outlets.

(e) Verify correct fan rotation.

(f) Test and record motor load in amps at various flow rate percentages.

(g) Make pitot tube traverses of main supply ducts to determine fan delivery. Obtain design air flow at 50% dirty filter condition (simulate).

(h) Repeat for 90%, 80% and 70% of design flow, at constant design static pressures.

(i) Measure and record supply air temperature (WB & DB) and return air temperature (WB & DB).

(j) Measure Total Static Pressure and discharge static pressures at branch outlets for each flow condition.

(k) Measure outdoor air volume and return air volume through the outdoor air damper and room return air opening respectively, for each flow condition.

(l) Measure and record chilled water entering and leaving temperatures.

3. Outdoor Air Supply Systems:

(a) Note: Outdoor air supply systems must be balanced with General Exhaust and Toilet Exhaust systems operating at their design levels.

(b) Test and adjust fan RPM to design requirements.

(c) Verify correct fan rotation.

(d) Test and record motor load in amps in various flow rate percentages.

(e) Make pitot tube traverses of main supply ducts to determine fan delivery. Measure design flow at 50% dirty filter condition (simulate).

(f) Measure the static pressure profile of the air handling unit and system duct static pressure at selected points (minimum of 10) throughout the system, including points along the vertical riser shafts.

(g) Adjust and balance the motorized fresh air dampers in each MER or at each AC unit to obtain design flow. Dampers are two position, thus requiring adjustment of damper blade positioning linkage in the open position.

(h) After adjustments to dampers throughout the system have been made, re-check fan performance adjusting as necessary.

(i) Mark all damper settings.

4. General Exhaust Systems:

NOTE: Corresponding supply air systems shall be operating at their design levels during testing and balancing procedures.

(a) Test and adjust fan RPM to design requirement.

(b) Verify correct fan rotation.

(c) Test and record motor load in amps, at various flow rate percentages.

(d) Make pitot tube traverses of main exhaust ducts to determine fan delivery. Obtain design flow , make adjustments as necessary.

(e) Measure the system duct static pressure at selected points (minimum of 10) throughout the system, including points along the vertical riser shafts.

(f) Adjust and balance manual and motorized general exhaust air dampers on each floor level to obtain design air flow. Automatic dampers are of the two position type, thus requiring adjustment of damper blade positioning linkage in the open position.

(g) After adjustments to dampers throughout the system have been made, re-check fan performance, adjusting as necessary.

(h) Mark all damper settings.

5. Toilet Exhaust Systems

NOTE: Corresponding supply air systems shall be operating at their design levels during testing and balancing procedures.

(a) Test and adjust fan RPM to design requirements.

(b) Verify correct fan rotation.

(c) Test and record motor load in amps at various flow percentages.

(d) Make pitot tube traverses of main exhaust ducts to determine fan delivery. Obtain design flow, make adjustments as necessary.

(e) Measure the system duct static pressure at selected points (minimum of 10) throughout the system, including points along the vertical riser shafts.

(f) Adjust and balance manual volume control dampers in exhaust ductwork to obtain design, at each register.

(g) Measure air volume supplied into toilet through each of the transfer grilles.

(h) After adjustments to toilet exhaust ductwork registers etc. have been made re-check fan performance, adjusting as necessary.

(i) Mark all damper settings.

6. Miscellaneous Exhaust Systems (Including Fume Hood)

NOTE: Corresponding supply air systems shall be operating at their design levels during testing and balancing procedures.

(a) Test and adjust fan RPM to design requirements.

(b) Verify correct fan rotation.

(c) Test and record motor load in amps at various flow percentages.

(d) Make pitot tube traverses of main exhaust ducts to determine fan delivery. Obtain design flow, make adjustments as necessary.

(e) Installed fume hood fans shall be adjusted to CFM requirements as shown on plans and as specified. Tests of fume hood enclosures shall be made to determine required velocities across opening.

(f) Measure the system duct static pressure at selected points (minimum of 10) throughout the system, including points along the vertical riser shafts.

(g) Adjust and balance manual volume control dampers in exhaust ductwork to obtain design, at each register.

(h) After adjustments to exhaust registers etc. have been made re-check fan performance, adjusting as necessary.

(i) Mark all damper settings.

7. Water Systems: Prepare water systems for balancing as follows.

(a) Operate the piping systems, and make adjustment in controls and equipment, and complete necessary balancing to deliver not less than the water quantities shown on the drawings at each equipment item. Balance all water systems regulated on a pressure drop and flow measurement basis.

(1) Phase I

(i) Piping Systems: Operate the cooling and heating, systems and make adjustments in controls and equipment, and complete necessary balancing to deliver not less than the water quantities shown on the drawings at each equipment item.

(ii) Open manual valves to full open position except valves intended to be normally closed during system operation.

(iii) The installing contractor shall remove strainers and clean in the presence of this contractor.

(iv) Examine water in system and determine if water has been treated and cleaned. Secure certification from the water treatment supplier.

(v) Check pump rotation.

(vi) Check expansion tanks to determine not air bound and ensure system is full of water.

(vii) Check air vents at high points of water systems to ensure they are installed and operating freely. Bleed air from manual vents.

(viii) Set temperature controls for AC units calling for full flow.

(ix) Check and set, in cooperation with temperature control manufacturer's representative, design condenser, chilled, heating water temperature.

(x) Complete air balancing before actual water balance begins.

(xi) Check operation of automatic bypass valve.

(xii) Measure and record flow (GPM), suction and discharge pressures. At pumps. Advise Engineer if design flows can not be achieved.

Perform ‘block-tight’ no-flow test and record data.

(2) Test and Balance Procedure - Phase II:

(i) After completion of Phase I, proceed with Phase II as follows.

(ii) Set chilled water, and hot water pumps to proper delivery.

(iii) Adjust flow of chilled water and heating water through each air conditioning unit and/or heat exchanger.

(iv) Check and record leaving water temperatures and return water temperatures of heat exchanger, cooling towers, free cooling coils, evaporators and condensers. Reset to correct design temperatures.

(v) Check and record water temperatures at inlet side of coils. Note riser or drop of temperatures from source. Record supply and return temperatures.

(vi) Balance each water coil.

(vii) Where 3-way valves are installed, bypass flow shall be adjusted to same flow as through coil or heat exchanger circuit.

(viii) Upon completion of flow readings and adjustments at coils, mark settings and record data.

(3) Test and Balance Procedure - Phase III:

(i) Upon completion of Phases I and II, proceed with Phase III as follows.

1) After adjustments to coils are made, recheck settings at pumps and heat exchanger and readjust if required.

2) Install pressure gages on coils, read pressure drop through AC unit at set flow rate on call for full cooling. Set pressure drop across bypass valve to match coil full flow pressure drop.

3) Record and check following items at each element.

a) Inlet water temperature.

b) Outlet water temperature.

c) Pressure drop of AC unit.

d) Pressure drop across valve.

e) Pump operating suction and discharge pressures and final total discharge head.

f) List mechanical specifications of pumps.

g) Rated and actual running amperage of pump motor.

h) Water metering device readings.

i) Wet and dry bulb outdoor temperatures.

(ii) Air temperature tests in Phase I of Balancing Procedure shall be repeated and recorded in this Phase.

D. Reports and Records: Include records of flow measurements made during testing and balancing work. Provide complete set of marked-up balancing plans with report. Plans shall show air opening numbers, and flow station numbers that correspond to numbering system in balancing logs.

E. After completion mark adjusted position of each balancing valve and damper for permanent reference.

F. Keep system in operation for period of five days during which time final inspection will be made by the Owner. After completion mark adjusted position of each balancing valve and damper for permanent reference.

3.9 INDOOR AIR QUALITY TESTING

A. Equipment Specification:

1. An infrared photo acoustic analyzer shall be used to monitor for carbon dioxide, carbon monoxide, and total volatile organic compounds levels. It is a real time analyzer equipment. The sampling installation in the building shall extend into the outside air, supply air and return air of each central HVAC system. In tenant areas the sampling points shall be as close as possible to the occupants breathing zones.

2. Calibration shall be performed in accordance with manufacturer specifications and recommended procedures.

B. Application (Analytical Methodology)

1. The analytical method used shall be a direct reading of the infrared spectroscopy technique, which classifies different organic compounds by their ability to absorb energy of specific wavelengths in the infrared region, specifically, center wavelength 3.4 μm and 3.6 μm respectively, as well as determine carbon dioxide and carbon monoxide in parts per million (ppm). The sub detection levels of the instrument, in parts per million (ppm) and

milligrams per cubic meter (mg/m^3), shall be as follows:

(a) Carbon dioxide ≈ 1.7 ppm;

(b) Carbon monoxide ≈ 0.2 ppm;

(c) Total volatile organic compounds, center wavelength 3.4 μm = 0.036 mg/m^3. The instrument is calibrated for propane at this wavelength. The detection level of this filter is sensitive to changes in relative humidity.

(d) Total volatile organic compounds center wavelength 3.6 μm = 0.07 mg/m^3. The instrument is calibrated for formaldehyde at this wavelength.

C. Indoor Air Quality Periodic Testing - Tenant Space

1. Two different sampling strategies shall be used, time specific sampling and 24 hour Continuous Monitoring.

2. The first strategy shall be the collection of indoor gaseous air quality data from a floor at a specific point in time (known as Time Specific Sampling), providing a snapshot of ambient conditions which are to be compared to applicable indoor air quality standards for verification of compliance with operating parameters.

3. The second strategy (known as 24-Hour Continuous Monitoring) expands upon the first through the use of additional equipment and provides a 24-hour study of conditions on the floor. The enhanced data produced by this configuration provides a more comprehensive view of ambient conditions and can record transient conditions that occur any time during monitoring. A graphical representation of gas concentrations over the sampling period is provided as part of the report.

D. Time-Specific Sampling

1. Indoor Gaseous Air Quality Monitoring for carbon dioxide (CO_2), carbon monoxide (CO) and two classes of total volatile compounds (TVOC) utilizing air sampling and the Infra-red Photo acoustic Multi-Gas Analyzer shall be performed at 4 locations on each floor or every 10,000 feet, whichever is smaller as well as at the central HVAC equipment. This survey shall also include a visual inspection of the MER for parameters adversely affecting indoor air quality. The inspection should be focused on mechanical hygiene and should follow the parameters dictated by EPA’s guidelines such as the “Building Air Quality: A Guideline For Building Owners and Facilities Managers”.

2. 24-Hour Continuous Monitoring

(a) Continual monitoring of Gaseous Indoor Air Quality Parameters shall include: carbon dioxide (CO_2), carbon monoxide (CO) and two classes of total volatile organic compounds (TVOC). This monitoring shall be performed utilizing air sampling installations and Infra-red Photo-acoustic Multi-Gas Analyzer configured for continuous, unattended operation for a 24-hour period. This survey shall include a visual inspection of the MER for parameters adversely affecting indoor quality. The inspection should be focused on mechanical hygiene and should follow the parameters dictated by EPA's guidelines such as the "Building Air Quality' A Guideline For Building Owners and Facilities Managers".

END OF SECTION 15990