FCA rchitects Fearn-Clendaniel Architects, Inc.
6 Larch Avenue Suite 398 Wilmington DE 19804 (P) 302-998-7615

SMYRNA SCHOOL DISTRICT
BID No SSD22004-NC_NEWIS

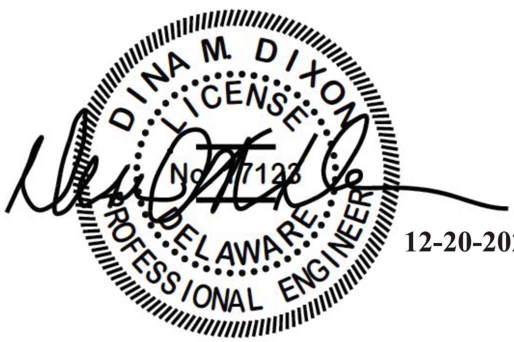
SPECIFICATIONS FOR

SUNNYSIDE INTERMEDIATE SCHOOL
New School

IN

70 GRACEVILLE DRIVE
SMYRNA, DELAWARE 19977

ARCHITECT'S PROJECT No 22019



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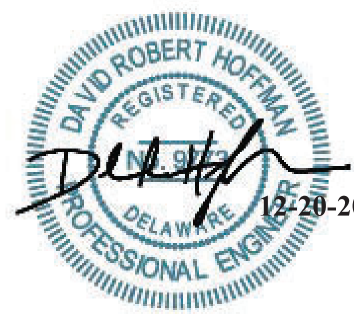
Volume 3



12-20-2024

PREPARED BY:
Fearn-Clendaniel Architects, Inc.

ISSUED FOR BIDDING/CONSTRUCTION

April 2025

DIVISION 21 SECTION 21 05 00
COMMON WORK RESULTS FOR FIRE PROTECTION
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SECTION 21 05 00 - COMMON WORK RESULTS FOR FIRE PROTECTION

PART 1. GENERAL

1.1. SUMMARY

A. All work under Division 21 is subject to the Division 01, General Conditions and Special Requirements for the entire contract.

B. Provide all labor, materials, equipment, and services necessary for and incidental to the complete installation and operation of all mechanical work.

C. Unless otherwise specified, all submissions shall be made to, and acceptances and approvals made by the Architect.

D. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions and accessories are not necessarily shown. Furnish and install all such items as may be required to fit the work to the conditions encountered. Arrange piping, equipment, and other work generally as shown on the contract drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawings for approval in accordance with Submittals specified below. The right is reserved to make reasonable changes in location of equipment, and piping up to the time of rough-in or fabrication.

E. Conform to the requirements of all rules, regulations and codes of local, state and federal authorities having jurisdiction.

F. Coordinate the work under Division 21 with the work of all other construction trades.

G. Be responsible for all construction means, methods, techniques, procedures, and phasing sequences used in the work. Furnish all tools, equipment and materials necessary to properly perform the work in first class, substantial, and workmanlike manner, in accordance with the full intent and meaning of the contract documents.

1.2. PERMITS AND FEES

A. Obtain all permits and pay taxes, fees and other costs in connection with the work. File necessary plans, prepare documents, give proper notices and obtain necessary approvals. Deliver inspection and approval certificates to Owner prior to final acceptance of the work.

B. Permits and fees shall comply with the Division 01, General Requirements of the specification.

1.3. EXAMINATION OF SITE

A. Examine the site, determine all conditions and circumstances under which the work must be done, and make all necessary allowances for same. No additional cost to the Owner will be permitted for Contractors failure to do so.

B. Examine and verify specific conditions described in individual specifications sections.

C. Verify that utility services are available, of the correct characteristics, and in the correct locations.

1.4. CONTRACTOR QUALIFICATION

A. Any Contractor or Subcontractor performing work under Division 21 shall be fully qualified and acceptable to the Architect and Owner. Submit the following evidence when requested:

1. A list of not less than five comparable projects which the Contractor completed.
2. Letter of reference from not less than three registered professional engineers, general contractors or building owners.
3. Local and/or State License, where required.
4. Membership in trade or professional organizations where required.

B. A Contractor is any individual, partnership, or corporation, performing work by contract or subcontract on this project.

C. Acceptance of a Contractor or Subcontractor will not relieve the Contractor or subcontractor of any contractual requirements or his responsibility to supervise and coordinate the work, of various trades.

1.5. MATERIALS AND EQUIPMENT

A. Materials and equipment installed as a permanent part of the project shall be new, unless otherwise indicated or specified, and of the specified type and quality.

B. Where material or equipment is identified by proprietary name, model number and/or manufacturer, furnish named item, or its equal, subject to approval by Engineer. Substituted items shall be equal or better in quality and performance and must be suitable for available space, required arrangement, and application. Submit all data necessary to determine suitability of substituted items, for approval.

C. The suitability of named item only has been verified. Where more than one item is named, only the first named item has been verified as suitable. Substituted items, including items other than first named shall be equal or better in quality and performance to that of specified items, and must be suitable for available space, required arrangement and application. Contractor, by providing other than the first named manufacturer, assumes responsibility for all necessary adjustments and modifications necessary for a satisfactory installation. Adjustments and modifications shall include but not be limited to electrical, structural, support, and architectural work.

D. Substitution will not be permitted for specified items of material or equipment where noted.

E. All items of equipment furnished shall have a service record of at least five (5) years.

1.6. FIRE SAFE MATERIALS

A. Unless otherwise indicated, materials and equipment shall conform to UL, NFPA and ASTM standards for fire safety with smoke and fire hazard rating not exceeding flame spread of 25 and smoke developed of 50.

1.7. REFERENCED STANDARDS, CODES AND SPECIFICATIONS

A. Specifications, Codes and Standards listed below are included as part of this specification, latest edition.

B. ASTM - American Society for Testing and Materials

C. FM - Factory Mutual

D. IBC - International Building Code

E. IEEE - Institute of Electrical and Electronics Engineers

F. MSSP - Manufacturers Standards Society of the Valve and Fittings Industry

G. NEC - National Electrical Code

H. NEMA - National Electrical Manufacturers Association

I. NFPA - National Fire Protection Association

J. UL - Underwriters' Laboratories

K. State of Delaware Fire Protection Requirements.

L. All equipment materials, piping and installation shall comply with the codes and standards listed in the enforceable edition of the Applicable National Fire Protection Association Pamphlets.

M. Fire Protection Systems design, equipment and installation shall comply with the Delaware State Fire Prevention Regulations, latest edition including all Annexes and Addendums.

1.8. SUBMITTALS, REVIEW AND ACCEPTANCE

A. Equipment, materials, installation, workmanship and arrangement of work are subject to review and acceptance. No substitution will be permitted after acceptance of equipment or materials except where such substitution is considered by the Architect to be in best interest of Owner.

B. After acceptance of Material and Equipment List, submit six (6) copies or more as required under General Conditions of complete descriptive data for all items. Data shall consist of specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, wiring diagrams, installation instructions, and any other information necessary to indicate complete compliance with Contract Documents. Edit submittal data specifically for application to this project.

C. Thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission. Coordinate installation requirements and any electrical requirements for equipment submitted. Contractor shall be responsible for correctness of all submittals.

D. Submittals will be reviewed for general compliance with design concept in accordance with contract documents, but dimensions, quantities, or other details will not be verified.

E. Identify submittals, indicating intended application, location and service of submitted items. Refer to specification sections or paragraphs and drawings where applicable. Clearly indicate exact type, model number, style, size and special features of proposed item. Submittals of a general nature will not be acceptable. For substituted items, clearly list on the first page of the submittal all differences between the specified item and the proposed item. The contractor shall be responsible for corrective action and maintaining the specification requirements if differences have not been clearly indicated in the submittal.

F. Submit actual operating conditions or characteristics for all equipment where required capacities are indicated. Factory order forms showing only required capacities will not be acceptable. Call attention, in writing, to deviation from contract requirements.

G. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted. Use only final or corrected submittals and data prior to fabrication and/or installation.

H. For any submittal requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.

I. For resubmissions, the Contractor must address in writing all of the Engineer’s comments on the original submission to verify compliance.

1.9. SHOP DRAWINGS

A. Prepare and submit shop drawings for all mechanical equipment, specially fabricated items, modifications to standard items, specially designed systems where detailed design is not shown on the contract drawings, or where the proposed installation differs from that shown on contract drawings.

B. Submit data and shop drawings including but not limited to the list below, in addition to provisions of the paragraph above. Identify all shop drawings by the name of the item and system and the applicable specification paragraph number and drawing number.

C. Every submittal including, but not limited to the list below, shall be forwarded with its own transmittal as a separate, distinct shop drawing. Grouping of items/systems that are not related shall be unacceptable.

D. Items and Systems

1. Access Doors/Panels including layout and location
2. Alarm Check Valves
3. Backflow Preventers
4. Blind Flange
5. Coordinated Drawings
6. Drip Pans

7. Exterior Equipment/Piping Supports
8. Fire Protection System including Hydraulic Calculations, Equipment and Devices
9. Fire Pump and Accessories
10. Fire Pump Controller and automatic transfer switch
11. Fire Stopping - Methods and Materials
12. Flowmeter and Primary Elements (Flow Fittings)
13. Gongs
14. Hose Valve Cabinets and Hose Valves
15. Identification System
16. Jockey Pump/controllers
17. Material and Equipment List
18. Operations and Maintenance Manuals
19. Pipe Materials Including Itemized Schedule
20. Preliminary and Final Pipe Pressure Tests
21. Pressure Gauges
22. Pressure Relief Valves
23. Pump Pressure Switches
24. Pumps
25. Sprinkler Heads
26. Standpipes
27. Strainers
28. Test Certificates
29. Valves
30. Vibration Isolation Materials
31. Weatherproof Assembly Components
32. Wiring Diagrams, Flow Diagrams and Operating Instructions
33. Zone Valve Assemblies

E. Contractor, additionally, shall submit for review any other shop drawings as required by the Architect. No item shall be delivered to the site, or installed, until the Contractor has received a submittal from the Engineer marked Reviewed or Comments Noted. After the proposed materials have been reviewed, no substitution will be permitted except where approved by the Architect.

F. For any shop drawing requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.

1.10. SUPERVISION AND COORDINATION

A. Provide complete supervision, direction, scheduling, and coordination of all work under the Contract, including that of subcontractors.

B. Coordinate rough-in of all work and installation of sleeves, anchors, and supports for piping, equipment, and other work performed under Division 21.

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

D. Coordinate electrical work required under Division 21 with that under Division 26.

Coordinate all work under Division 21 with work under all other Divisions.

E. Supply services of an experienced (10 years minimum) and competent Project Manager to be in constant charge of work at site.

F. Where a discrepancy exists within the specifications or drawings or between the specifications and drawings, the more stringent (or costly) requirement shall apply until clarification can be obtained from the Engineer. Failure to clarify such discrepancies with the Engineer will not relieve the Contractor of the responsibility of conforming to the requirements of the Contract.

G. Failure of contractor to obtain a full and complete set of contract documents (either before or after bidding) will not relieve the contractor of the responsibility of complying with the intent of the contract documents.

H. Coordinate installation of large equipment requiring positioning before closing in building.

1.11. CUTTING AND PATCHING

A. Accomplish all cutting and patching necessary for the installation of work under Division 21. Damage resulting from this work to other work already in place, shall be repaired at Contractor's expense. Where cutting is required, perform work in neat and workmanlike manner. Restore disturbed work to match and blend with existing construction and finish, using materials compatible with the original. Use mechanics skilled in the particular trades required.

B. Do not cut structural members without approval from the Architect or Structural Engineer.

1.12. PENETRATION OF WATERPROOF CONSTRUCTION

A. Coordinate the work to minimize penetration of waterproof construction, including roofs, exterior walls, and interior waterproof construction. Where such penetrations are necessary, furnish and install all necessary curbs, sleeves, flashings, fittings and caulking to make penetrations absolutely watertight.

B. Where pipes penetrate roofs, flash pipe with Stoneman Stormtite, Pate or approved equal, roof flashing assemblies with skirt and caulked counter flashing sleeve.

C. Furnish and install pitch pockets or weather tight curb assemblies where required.

D. Furnish and install curbs, specifically designed for application to the particular roof construction, and install in accordance with the manufacturer's instructions. The Contractor shall be responsible for sleeve sizes and locations. All roof penetrations shall be installed in accordance with manufacturer’s instructions, the National Roofing Contractors Association, SMACNA, and as required by other divisions of these specifications.

1.13. CONCRETE AND MASONRY WORK

A. Furnish and install concrete and masonry work for equipment foundations, supports, pads, and other items required under Division 21. Perform work in accordance with requirements of other applicable Divisions of these specifications.

B. Concrete shall test not less than 3,000 psi compressive strength after 28 days.

C. Grout shall be non-shrink, high strength mortar, free of iron of chlorides and suitable for use in contact with all metals, without caps or other protective finishes. Apply in accordance with manufacturer's instructions and standard grouting practices.

1.14. CONNECTIONS AND ALTERATIONS TO EXISTING WORK

A. Unless otherwise noted on the drawings, where existing fire protection work is removed, pipes, valves, etc., shall be removed, including hangers, to a point below finished floors or behind finished walls and capped. Such point shall be far enough behind finished surfaces to allow for installation of normal thickness of required finish material.

B. Where work specified in Division 21 connects to existing equipment and piping, etc., Contractor shall perform all necessary alterations, cuttings, fittings, etc., of existing work as may be necessary to make satisfactory connections between new and existing work, and to leave completed work in a finished and workmanlike condition.

C. Where the work specified under Division 21, or under other Divisions, requires relocation of existing equipment, piping, etc., Contractor shall perform all work and make necessary changes to existing work as may be required to leave completed work in a finished and workmanlike condition.

D. Where the relocation of existing equipment is required for access or the installation of new equipment, the contractor shall temporarily remove and/or relocate and re-install as required to leave the existing and new work in a finished and workman like condition.

1.15. DEMOLITION

A. Unless otherwise noted all existing equipment, piping, etc., shall remain.

B. Where existing equipment is indicated to be removed, all associated piping, conduit, power, controls, insulation, hangers, supports and housekeeping pads, etc. Patch, paint and repair walls/roof/floor to match existing and/or new finishes.

C. Provide necessary piping, valves, temporary feeds, etc., as required. Drain and refill piping systems as often as necessary to accommodate phasing and to minimize time lengths of outages.

D. The Contractor shall be responsible for visiting the site and determining the existing conditions in which the work is to be performed.

E. Where any abandoned pipes in existing floors, walls, pipe tunnels, ceilings, etc., conflict with new work, remove abandoned pipes as necessary to accommodate new work.

F. The location of all existing equipment, piping, etc., indicated is approximate only and shall be checked and verified. Install all new fire protection work to connect to or clear existing work as applicable.

G. Maintain egress at all times. Coordinate egress requirements with the State Fire Marshal, the Owner and the authorities having jurisdiction.

H. Make provisions and include in bid all costs associated with confined entry/space requirements in and all other applicable OSHA regulations.

I. Where required to maintain the existing systems in operation, temporarily backfeed existing systems from new equipment. Contractor shall temporarily extend existing piping systems to new piping systems with the appropriate shut-off valves and tamper switches.

J. At completion of project all temporary piping, valves, controls, etc., shall be removed in their entirely.

K. Existing piping, equipment, materials, etc., not required for re-use or re-installation in this project, shall be removed from the project site.

L. Deliver to the Owner, on the premises where directed, existing equipment and materials which are removed and which are desired by the Owner or are indicated to remain the property of the Owner.

M. All other materials and equipment which are removed shall become property of the Contractor and shall be promptly removed, from the premises, and disposed of by the Contractor, in an approved manner.

N. Where piping is removed, remove all pipe hangers which were supporting the removed piping. Patch the remaining penetration voids with like materials and paint to match existing construction.

O. Before demolition begins, and in the presence of the Owners representative, test and note all deficiencies in all existing systems affected by demolition but not completely removed by demolition. Provide a copy of the list of system deficiencies to the Owner and the Engineer. Videotape existing conditions in each space prior to beginning demolition work.

P. The Owner shall have the first right of refusal for all devices and equipment removed by the Contractor.

Q. All devices and equipment designated by the Owner to remain the property of the Owner shall be moved and stored by the Contractor at a location on site as designated by the Owner. It shall be the Contractor's responsibility to store all devices and equipment in a safe manner to prevent damage while stored.

R. All existing equipment refused by the Owner shall become the property of the Contractor and shall be removed from the site by the Contractor in a timely manner and disposed of in a legal manner.

S. Work Abandoned in Place: cut and remove underground pipe a minimum of 2 inches beyond face of adjacent construction. Cap and patch surface to match existing finish.

T. Temporary Disconnection: Remove, store, clean, reinstall, reconnect, and make operational equipment indicated for relocation.

U. Terminate services and utilities in accordance with local laws, ordinances, rules and regulations.

1.16. EXCAVATION AND BACKFILLING

A. General

1. Perform all necessary excavation, or installation of work under Division 21, in whatever materials or conditions encountered, using suitable methods and equipment.
2. Accurately establish required lines and grades and properly locate the work.
3. Determine the locations of all existing utilities before commencing the work.

B. Excavation: (Refer also to other portions of the specifications)

1. Excavate only the required elevations. If excavation is carried below the foundation lines or other required limits, backfill the excess with concrete.
2. Keep banks of trenches as nearly vertical as possible, and provide sheeting and/or shoring as required for protection of work and safety of personnel. Follow local, State, OSHA Guidelines.
3. Keep excavations dry. Protect excavations from freezing.

C. Backfilling: (Refer also to other portions of the specifications)

1. Backfill excavations to the required elevations and restore surfaces to their original or required conditions.
2. Backfill shall be similar material, free from objectionable matter such as rubbish, roots, stumps, brush, rocks and other sharp objects. Unless otherwise indicated, suitable material from the excavation may be used for backfill.
3. Carefully place and mechanically tamp backfill in layers not exceeding 12 inches loose thickness. Compact to 95 percent minimum.
4. Do not backfill against frozen material. Do not use frozen material for backfill.

1.17. DRIVE GUARDS

A. Provide safety guards on all exposed belt drives, motor couplings, and other rotating machinery. Provide fully enclosed guards where machinery is exposed from more than one direction.

B. When available, guards shall be factory fabricated and furnished with the equipment. Otherwise fabricate guards of heavy gauge steel, rigidly braced, removable, and finish to match equipment served. Provide openings for tachometers. Guards shall meet local, State and O.S.H.A. requirements.

1.18. VIBRATION ISOLATION

A. Furnish and install vibration isolators, flexible connections, supports, anchors and/or foundations required to prevent transmission of vibration from equipment, or piping to building structure. See Division 23 Section, “Vibration Control for HVAC Plumbing and Fire Protection Equipment”.

1.19. ALTERNATES

A. Refer to Division 01 Section, “Alternates” for description of work under this section affected by alternates

1.20. DEFINITIONS

A. Approve - to permit use of material, equipment or methods conditional upon compliance with contract documents requirements.

B. Furnish and install or provide means to supply, erect, install, and connect to complete for readiness for regular operation, the particular work referred to.

C. Contractor means the mechanical contractor and any of his subcontractors, vendors, suppliers, or fabricators.

D. Piping includes pipe, all fittings, valves, hangers, insulation, identification, and other accessories relative to such piping.

E. Concealed means hidden from sight in chases, formed spaces, shafts, hung ceilings, embedded in construction.

F. Exposed means not installed underground or concealed as defined above.

G. Invert Elevation means the elevation of the inside bottom of pipe.

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

I. Review - limited observation or checking to ascertain general conformance with design concept of the work and with information given in contract documents. Such action does not constitute a waiver or alteration of the contract requirements.

J. Building Line: Exterior wall of building.

1.21. FUTURE ADDITIONS

A. Where future additions are indicated, size, calculate, and install all piping to account for future additions. Furnish and install control valve with tamper switch in ceiling adjacent to future additions. Provide cap at the end of the piping. Arrange so that in the future the cap can be removed and control valve opened to serve future additions without draining system.

PART 2. ELECTRICAL REQUIREMENTS

2.1. GENERAL MOTOR AND ELECTRICAL REQUIREMENTS

A. Furnish and install control and interlock wiring for the equipment furnished. In general, power wiring and motor starting equipment will be provided under Division 26. Carefully review the contract documents to coordinate the electrical work under Division 21 with the work under Division 26. Where the electrical requirements of the equipment furnished differ from the provisions made under Division 26, make the necessary allowances under Division 21. Where no electrical provisions are made under Division 26, include all necessary electrical work under Division 21.

B. All electrical work performed under Division 21 shall conform to the applicable requirements of Division 26 and conforming to the National Electrical Code. All wiring, conduit, etc., installed in ceiling plenums must be plenum rated per NFPA and the IBC.

C. Provide wiring diagrams with electrical characteristics and connection requirements.

D. Test Reports: Indicate test results verifying nominal efficiency and power factor for three phase motors larger than five (5) horsepower.

E. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof covering. For extended outdoor storage, remove motors from equipment and store separately.

F. All motors shall be furnished with visible nameplate indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor and efficiency.

G. Nominal efficiency and power factor shall be as scheduled at full load and rated voltage when tested in accordance with IEEE 112.

H. Brake horsepower load requirement at specified duty shall not exceed 85 percent of nameplate horsepower times NEMA service factor for motors with 1.0 and 1.15 service factors.

I. All single phase motors shall be provided with thermal protection: Internal protection shall automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature ratings of motor insulation. Thermal protection device shall automatically reset when motor temperature returns to normal range, unless otherwise indicated.

J. Where equipment under this Division is specified with integral disconnecting means, the same shall be a single disconnecting means for disconnecting all ungrounded main power supply conductors that is capable of being locked in the open ("off") position in accordance with the National Electrical Code and the local electrical inspector.

2.2. MOTORS AND CONTROLS

A. Motors and controls shall conform to the latest requirements of IEEE, NEMA, NFPA-70 and shall be UL listed. Motor sizes are specified with the driven equipment. Motor starting and control equipment is specified either with the motor which is controlled or in an electrical specification section. The Contractor is advised to consult all specification sections to determine responsibility for motors and controls.

B. Motors shall be designed, built and tested in accordance with the latest revision of NEMA Standard MG l.

C. Motors shall be suitable for use under the conditions and with the equipment to which applied, and designed for operation on the electrical systems specified or indicated.

1. Motor capacities shall be such that the horsepower rating and the rated full-load current will not be exceeded while operating under the specified operating conditions. Under no condition shall the motor current exceed that indicated on the nameplates.
2. Motor sizes noted in the individual equipment specifications are minimum requirements only. It is the responsibility of the equipment manufacturers and of the Contractor to furnish motors, electrical circuits and equipment of ample capacity to operate the equipment without overloading, exceeding the rated full-load current, or overheating at full-load capacity under the most severe operating service of this equipment. Motors shall have sufficient torque to accelerate the total WR2 of the driven equipment to operating speed.
3. Motors shall be continuous duty type and shall operate quietly at all speeds and loads.
4. Motors shall be designed for operation on 60 hertz power service. Unless otherwise specified or shown, motors less than ½ horsepower shall be single phase, and motors ½ horsepower and larger shall be 3 phase unless otherwise noted.
5. Motors shall be mounted so that the motor can be removed without removing the entire driven unit.

D. Single phase motors, smaller than 1/20 horsepower shall be ball or sleeve bearing; drip-proof, totally enclosed or explosion proof, as specified; 120 volts; permanent-split capacitor or shaded pole type. These motors shall not be used for general power purposes, and shall only be provided as built-in components. When approved by the Engineer, deviations from the specifications will be permitted as follows:

1. Open motors may be installed as part of an assembly where enclosure within a cabinet provides protection against moisture.
2. Motors used in conjunction with low voltage control systems may have a voltage rating less than 115 volts.

E. Single phase motors, greater than 1/20 horsepower and less than ½ horsepower shall be ball bearing; drip-proof, totally enclosed or explosion proof, as specified, with Class A or B insulation, as standard with the motor manufacturer; 115 or 120/208/240 volts as required; capacitor start-induction run, permanent split capacitor, or repulsion start-induction run type with minimum efficiency of 70 percent and a minimum full load power of 77 percent.

F. Except as otherwise specified in the various specification sections, 3 phase motors 60 horsepower and smaller shall be NEMA design B squirrel cage induction type meeting the requirements of this paragraph. Motors shall be drip-proof, totally enclosed or explosion proof, as specified or indicated. Insulation shall be Class B or F, at 40 degrees C ambient temperature. Drip-proof motors shall have a 1.15 service factor and totally enclosed and explosion proof motors shall have a service factor of 1.00 or higher. Motors specified for operation at 480, 240, and 208 volts shall be name-plated 460, 230, 200 volts, respectively. Efficiencies and percent power factor at full load for three phase motors shall be not less than the values listed below for premium efficiency motors:

MOTOR NAMEPLATE	MINIMUM PERCENT EFFICIENCY AT NOMINAL SPEED AND RATED LOAD	MINIMUM PERCENT POWER FACTOR
1HP and above to	85.5 percent	84 percent
1-½ HP	86.5 percent	85 percent
2HP	86.5 percent	85 percent
3HP	89.5 percent	86 percent
5HP	89.5 percent	87 percent
7½ HP	91 percent	86 percent
10HP	91.7 percent	85 percent
15HP	93.0 percent	85 percent
20HP	93.0 percent	86 percent
25HP	93.6 percent	85 percent
50HP and above	94.5 percent	88 percent

G. Three phase motors ½ HP or greater shall be the Duty Master XE by Reliance Electric Company, Super-E Premium Efficiency of Baldor Motor and Drives, E-plus Efficient Standard Duty Motor of the Electric Motor Division of Gould, Inc., the MAC II High Efficiency motor of Westinghouse Electric Corp., the equivalent product of General Electric, or approved equal.

H. Motor frames shall be NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast-iron or aluminum with steel inserts.

2.3. MOTOR INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Install securely on firm foundation. Mount ball bearing motors to support shaft regardless of shaft position.

C. Check line voltage and phase and ensure agreement with nameplate. Check that proper thermal overloads have been installed prior to operating motors.

2.4. WIRING DIAGRAMS

A. The Contractor is responsible for obtaining and submitting wiring diagrams for all major items of equipment.

B. Wiring diagrams shall be provided with shop drawings for all equipment requiring electric power.

2.5. ENCLOSURES

A. Electrical enclosures including factory provided enclosures, field provided and installed enclosures, and automatic temperature control system enclosures shall be as follows:

1. Dry Interior Locations: NEMA 1.
2. Damp/Wet Locations, Including Exterior Locations: NEMA 3R.
3. Corrosive Locations, Including Chemical Storage Rooms and Similar Space = NEMA 4X.

PART 3. EXECUTION

3.1. EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to provide maximum possible headroom, if 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 Architect.

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

D. Install fire protection 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.

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

F. Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.

G. Do not install equipment or piping over electrical gear, electrical panels, motor controllers, and similar electrical equipment. Install equipment and piping to maintain clear space above and in front of all electrical components per the National Electric Code.

3.2. SUPPORTS, HANGERS AND FOUNDATIONS

A. Provide supports, hangers, braces, attachments and foundations required for the work. Support and set the work in a thoroughly substantial and workmanlike manner without placing strains on materials, equipment, or building structure, submit shop drawings for approval. Coordinate all work with the requirements of the structural division.

B. Supports, hangers, braces, and attachments shall be standard manufactured items or fabricated structural steel shapes. All interior hangers shall be galvanized or steel with rust inhibiting paint. For un-insulated copper piping provide copper hanger to prevent contact of dissimilar metals. All exterior hangers shall be stainless steel including hangers, rods, nuts, washers, bolts, etc.

C. Concrete housekeeping pads and foundations shall be not less than 4 inches high and shall extend a minimum of 6 inches beyond equipment bases. Provide wire-mesh reinforcement; chamfer exposed edges and corners; and finish exposed surfaces smooth.

3.3. DEMONSTRATION AND TRAINING VIDEO RECORDINGS

A. General: Record demonstration and training video recordings. Record each training module separately.

1. At beginning of each training module, record each chart containing learning objective and lesson outline.

B. Video Recording Format: Provide high-quality color video recordings with menu navigation in format acceptable to Engineer

C. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to show area of demonstration and training. Display continuous running time.

D. Narration: Describe scenes on video recording by audio narration by microphone while video recording is recorded. Include description of items being viewed.

E. Transcript: Provide a transcript of the narration. Display images and running time captured from videotape opposite the corresponding narration segment.

3.4. PROVISIONS FOR ACCESS

A. The contractor shall provide access panels and doors for all concealed equipment, valves, strainers, controls, control devices, and other devices requiring maintenance, service, adjustment, balancing or manual operation.

B. Where access doors are necessary, furnish and install manufactured painted steel door assemblies consisting of hinged door, key locks, and frame designed for the particular wall or ceiling construction. Properly locate each door. Door sizes shall be a minimum of 12 inches x 12 inches for hand access, 18 inches x 18 inches for shoulder access and 20 inches x 30 inches for full body access where required. Review locations and sizes with Architect prior to fabrication. Provide U.L. approved and labeled access doors where installed in fire rated walls or ceilings. Doors shall be Milcor Metal Access Doors as manufactured by Inland-Ryerson, Mifab, or approved equal.

1. Acoustical or Cement Plaster: Style B
2. Hard Finish Plaster: Style K or L
3. Masonry or Dry Wall: Style M

C. Where access is by means of liftout ceiling tiles or panels, mark each ceiling grid using small color-coded and numbered tabs. Provide a chart or index for identification. Place markers within ceiling grid not on ceiling tiles.

D. Access panels, doors, etc. described herein shall be furnished under the section of specifications providing the particular service and to be turned over to the pertinent trade for installation. Coordinate installation with installing contractor. All access doors shall be painted in baked enamel finish to match ceiling or wall finish.

E. Submit shop drawings indicating the proposed location of all access panels/doors. Access doors in finished spaces shall be coordinated with air devices, lighting and sprinklers to provide a neat and symmetrical appearance.

F. Where access doors are installed in wet locations (i.e. shower rooms, toilet rooms, kitchens, dishwasher rooms, can wash rooms, natatoriums, and similar spaces, etc.) provide aluminum access doors/frames.

3.5. PAINTING AND FINISHES

A. Provide protective finishes on all materials and equipment. Use coated or corrosion-resistant materials, hardware and fittings throughout the work. Paint bare, untreated ferrous surfaces with rust-inhibiting paint. All exterior components including supports, hangers, nuts, bolts, washers, vibration isolators, etc. shall be stainless steel.

B. Clean surfaces prior to application of insulation, adhesives, coatings, paint, or other finishes.

C. Provide factory-applied finishes where specified. Unless otherwise indicated factory-applied paints shall be baked enamel with proper pretreatment.

D. Protect all finishes and restore any finishes damaged as a result of work under Division 21 to their original condition.

E. The preceding requirements apply to all work, whether exposed or concealed.

F. Remove all construction marking and writing from exposed equipment, piping and building surfaces. Do not paint manufacturer's labels or tags.

G. All exposed piping, equipment, etc. shall be painted. Colors shall be as stated in this division or as selected by the Architect in Division 09 and conform to ANSI Standards.

H. All exposed piping, equipment, etc. in finished spaces shall be painted. Colors shall be as selected by the Architect and conform to ANSI Standards.

I. Refer to Division 09 for additional painting requirements.

J. Paint perimeter of all housekeeping pads safety yellow.

3.6. CLEANING OF SYSTEMS

A. Thoroughly clean systems after satisfactory completion of pressure tests and before permanently connecting equipment, and other accessory items. Blow out and flush piping until interior surfaces are free of foreign matter.

B. Flush piping to remove cutting oil, excess pipe joint compound, solder slag and other foreign materials. Do not use system pumps until after cleaning and flushing has been accomplished to the satisfaction of the Engineer. Employ chemical cleaners, including a non-foaming detergent, not harmful to system components. After cleaning operation, final flushing and refilling, the residual alkalinity shall not exceed 300 parts per million. Submit a certificate of completion to Engineer stating the name of service company used.

C. Pay for labor and materials required to locate and remove obstructions from systems that are clogged with construction refuse after acceptance. Replace and repair work disturbed during removal of obstructions.

D. Leave systems clean, and in complete running order.

3.7. COLOR SELECTION

A. Color of finishes shall be as selected by the Architect.

B. Submit color of factory-finished equipment for acceptance prior to ordering.

3.8. PROTECTION OF WORK

A. Protect work, material and equipment from weather and construction operations before and after installation. Properly store and handle all materials and equipment.

B. Cover temporary openings in piping and equipment to prevent the entrance of water, dirt, debris, or other foreign matter. Deliver pipes and tubes with factory applied end caps.

C. Cover or otherwise protect all finishes.

D. Replace damaged materials, devices, finishes and equipment.

E. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, where stored inside.

3.9. OPERATION OF EQUIPMENT

A. Clean all systems and equipment prior to initial operation for testing, or other purposes. Lubricate, adjust, and test all equipment in accordance with manufacturer's instructions. Do not operate equipment unless all proper safety devices or controls are operational. Provide all maintenance and service for equipment that is authorized for operation during construction.

B. Where specified, or otherwise required, provide the services of the manufacturer's factory-trained servicemen or technicians to start up the equipment. Where factory start-up of equipment is not specified, provide field start-up by qualified technician.

C. Submit factory start-up sheets or field start-ups sheets for all equipment.

3.10. IDENTIFICATIONS, FLOW DIAGRAMS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS

A. Contractor shall submit for approval working fire protection drawings of each piping system installed in the building. Diagrams shall indicate the location and the identification number of each valve in the particular system. Following approval by all authorities, the diagrams shall be framed, mounted under safety glass and hung in each Mechanical Room where directed. Contractor shall deliver the tracing or sepia from which the diagrams were reproduced to the Owner.

B. All valves shall be plainly tagged. For any bypass valves, install sign indicating valve position as "Normally Open" or "Normally Closed" as required.

C. All items of equipment, including motor starters, fire pump controllers, jockey pump controllers, and disconnects shall be furnished with white on black plastic permanent identification cards. Lettering shall be a minimum of ¼ inch high. Identification plates shall be secured, affixed to each piece of equipment, starters, disconnects, panels by screw or adhesive (tuff bond #TB2 or as approved equal). Equipment identification and room name or area served shall be on each label.

D. Provide six (6) hard copies and one (1) electronic copy of operating and maintenance instructions for all principal items of equipment furnished. This material shall be bound as a volume of the Operation and Maintenance Booklet as hereinafter specified.

E. All piping installed under this contract shall be stenciled with direction of flow arrows and with stenciled letters naming each pipe and service. Refer to Division 21 Section, "Fire Suppression System Piping, Fittings, Valves, Etc". Color code all direction of flow arrows and labels. In finished spaces omit labeling and direction of flow arrows. Paint in color as selected by Architect.

F. Submit list of wording, symbols, letter size, and color coding for fire protection identification. Submit samples of equipment identification cards, piping labels, and valve tags to Engineer for review prior to installation.

G. Provide at least eight (8) hours of straight time instruction to the operating personnel. Time of instruction shall be designated by the Owner.

H. Contractor shall demonstrate Sequences of Operation of all fire protection equipment in presence of Owner's representative, and Fire Marshal.

3.11. WALL AND FLOOR PENETRATION

A. All penetrations of partitions, ceilings, roofs and floors by piping or conduit under Division 21 shall be sleeved, sealed, and caulked airtight for sound and air transfer control.

B. All penetration of fire rated assemblies shall be sleeved, sealed, caulked and protected to maintain the rating of the wall, roof, or floor. Fire Marshal approved U.L. assemblies shall be utilized. See Division 07 Section, "Fire Protection, HVAC and Plumbing Protection Firestopping".

C. Where piping extends through exterior walls or below grade, provide waterproof pipe penetration seals, as specified in another division of these specifications.

D. Provide pipe escutcheons for sleeved pipes in finished areas.

E. Piping sleeves:

1. Galvanized steel pipe, standard weight where pipes are exposed and roofs and concrete and masonry walls. On exterior walls provide anchor flange welded to perimeter.
2. Twenty-two (22) gauge galvanized steel elsewhere.

F. Extend all floor sleeves through floor at least 2-inches above finished floor, caulk sleeve the entire depth and furnish and install floor plate.

G. Sleeves for penetrations in kitchen and food service areas shall finish .375 inches above floor or flush with wall surfaces and be neatly pointed up to fit snuggly against floor or wall material.

3.12. RECORD DRAWINGS

A. Upon completion of the mechanical installations, the Contractor shall deliver to the Architect one complete set of prints of the fire protection drawings which shall be legibly marked in red pencil to show all changes and departures of the installation as compared with the original design. They shall be suitable for use in preparation of Record Drawings.

B. Contractor shall incorporate all sketches, addendums, value engineering, change orders, etc., into record drawings prior to delivering to Architect.

3.13. WARRANTY

A. Contractor's attention is directed to warranty obligations contained in the GENERAL CONDITIONS.

B. The above shall not in any way void or abrogate equipment manufacturer's guarantee or warranty. Certificates of equipment manufacturer’s warranties shall be included in the operations and maintenance manuals.

C. The contractor guarantees for a two (2) year period from the time of final acceptance by the Owner.

1. That the work contains no faulty or imperfect material or equipment or any imperfect, careless, or unskilled workmanship.
2. That all work, equipment, machines, devices, etc. shall be adequate for the use to which they are intended, and shall operate with ordinary care and attention in a satisfactory and efficient manner.
3. That the contractor will re-execute, correct, repair, or remove and replace with proper work, without cost to the Owner, any work found to be deficient. The contractor shall also make good all damages caused to their work or materials in the process of complying with this section.
4. That the entire work shall be water-tight and leak-proof.

3.14. LUBRICATION

A. All bearings, motors, and all equipment requiring lubrication shall be provided with accessible fittings for same. Before turning over the equipment to the Owner, the Contractor shall fully lubricate each item of equipment, shall provide one year's supply of lubricant for each, and shall provide Owner with complete written lubricating instructions, together with diagram locating the points requiring lubrication. Include this information in the Operations and Maintenance Booklet.

B. In general, all motors and equipment shall be provided with grease lubricated roller or ball bearings with Alemite or equal accessible or extended grease fittings and drain plugs.

3.15. OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall have prepared six (6) hardcopies and one (1) electronic copy of the Operation and Maintenance Manuals and deliver these copies of the manuals to the Owner. The manuals shall be as specified herein. The manuals must be approved and will not be accepted as final until so stamped.

B. The manuals shall be bound in a three ring loose-leaf binder similar to National No. 3881 with the following title lettered on the front: Operations and Maintenance Manuals – Smyrna School District – Sunnyside Intermediate School – Fire Protection. No sheets larger than 8-1/2 inches x 11 inches shall be used, except sheets that are neatly folded to 8-1/2 inches x 11 inches and used as a pull-out. Provide divider tabs and table of contents for organizing and separating information.

C. Electronic copies of the manual shall be saved on USB flash drives, and shall be in searchable PDF format with interactive index tabs. Approved electronic copies shall be stored in flash drive zipper cases in front of Volume 1 (if applicable) of hard copies of the manual.

D. Provide the following data in the booklet:

1. As first entry, an approved letter indicating the starting/ending time of Contractor's warranty period.
2. Maintenance operation and lubrication instructions on each piece of equipment furnished.
3. Manufacturer's extended limited warranties on equipment.
4. Chart form indicating frequency and type of routine maintenance for all fire protection equipment. The chart shall also indicate model number of equipment, location and service.
5. Provide sales and authorized service representatives names, address, and phone numbers of all equipment and subcontractors.
6. Provide supplier and subcontractor's names, address, and phone number.
7. Catalog data of all equipment, valves, etc. shall include wiring diagrams, parts list and assembly drawing.
8. Provide and install in locations as directed by the Owner, valve charts including valve tag number, valve type, valve model number, valve manufacturer, style, service and location. Each valve chart shall be enclosed in a durable polymer based frame with a cover safety glass.
9. Access panel charts with index illustrating the location and purpose of access panels.
10. Approved Fire Suppression System Certificates.
11. Start-up reports for equipment.
12. NFPA Test Reports.

E. Electronic copies of the manual shall be saved on USB flash drives, and shall be in searchable PDF format with interactive index tabs. Approved electronic copies shall be stored in flash drive zipper cases in front of volume 1 (if applicable) of hard copies of the manual.

F. Submit Operations and Maintenance Manuals prior to anticipated date of substantial completion for Engineer review and approval. Substantial completion requires that Operations and Maintenance Manuals be reviewed and approved.

3.16. INSTALLATION AND COORDINATION DRAWINGS

A. Prepare, submit, and use composite installation and coordination drawings to assure proper coordination and installation of work. Drawings shall include, but not be limited, to the following:

1. Complete Plumbing, Sprinkler and HVAC Piping Drawings showing coordination with lights, electrical equipment, HVAC equipment and structural amenities.

B. Draw plans to a scale not less than 3/8-inch equals one foot. Include plans, sections, and elevations of proposed work, showing all equipment, and piping in areas involved. Fully dimension all work including lighting fixtures, conduits, pullboxes, panelboards, and other electrical work, walls, doors, ceilings, columns, beams, joists and other architectural and structural work.

C. Identify all equipment and devices on wiring diagrams and schematics. Where field connections are shown to factory-wired terminals, include manufacturer's literature showing internal wiring.

3.17. PIPING SYSTEMS TESTING

A. The entire new fire protection piping systems shall be tested hydrostatically before insulation covering is applied and proven tight under the following gauge pressures for a duration of twenty-four (24) hours. Testing to be witnessed by Owner's representative and documented in writing.

SYSTEM	TEST PRESSURE
Fire Suppression Piping (Refer to NFPA)	200 psi

B. Testing and acceptance thereof shall be in accordance with local requirements and shall meet approval of authority having jurisdiction. Submit certificates and approved permits and insert one (1) copy in the Operations and Maintenance Manuals.

3.18. OUTAGES

A. Provide a minimum of fourteen (14) days notice to schedule outages. The Contractor shall include in their bid outages and/or work in occupied areas to occur on weekends, holidays, or at night. Coordinate and get approval of all outages with the Owner.

B. Submit Outage Request form, attached at end of this Section, to Owner for approval.

END OF SECTION

DIVISION 21 SECTION 21 05 05
FIRE SUPPRESSION SYSTEM PIPING, FITTINGS & VALVES
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SECTION 21 05 05 - FIRE SUPPRESSION SYSTEM PIPING, FITTINGS & VALVES

PART 1. GENERAL

1.1. SUMMARY

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SYSTEM DESCRIPTION CONDITIONS

A. Provide all labor and materials necessary to furnish and install all piping systems on this project as herein specified and/or shown on the drawings.

B. All piping and insulation installed in ceiling plenums must be plenum rated and comply with NFPA and the authority having jurisdiction.

C. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

D. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.

E. Use non-conducting dielectric connections whenever jointing dissimilar metals in open systems.

F. Provide pipe hangers and supports in accordance with ASTM B31.9, MSS SP69 and NFPA-13 unless indicated otherwise.

G. Use 3/4 inch (20 mm) ball valves with cap and chain for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest floor drain.

H. For areas subject to freezing (exterior canopy, covered porch, etc.), Contractor shall provide and install dry pipe heads, piping, control valves, tamper switches, test stations, and accessories, etc., required by NFPA-13 and the authority having jurisdiction. For small loops, antifreeze may be utilized if allowed by the authority having jurisdiction. Install piping, control valves, tamper switches, test stations, backflow preventers, expansion tanks, fill cup, drain valve, etc. as required by NFPA-13 and the authority having jurisdiction.

1.3. QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body.

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

C. If the product is available domestically it shall be supplied as such.

1.4. DELIVERY, STORAGE AND HANDLING

A. Deliver, store, protect and handle products to site under as hereinbefore specified.

B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

C. Provide temporary protective coating on cast iron and steel valves.

D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed systems.

1.5. ENVIRONMENTAL REQUIREMENTS

A. Do not install underground piping when bedding is wet or frozen.

1.6. EXTRA MATERIALS

A. Provide one (1) repacking kit for each size valve.

1.7. ALTERNATES

A. Refer to Division 01 Section, “Alternates” for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. PIPE MATERIALS

A. All materials, unless otherwise specified, shall be new and of the best quality of their respective kinds, and shall conform to the requirements and ordinances of local, state and insurance authorities having jurisdiction.

1. Fire Suppression System Piping (NFPA-13):

a. Piping Underground: Steel, schedule 40, ASTM A53, black pipe with ASME C105 polyethylene jacket or double layer, half-lapped 10 mil polyethylene tape, or listed ductile iron pipe.
b. Piping Above Grade (Inside): Steel, schedule 40, ASTM A53, black pipe. Piping 4 inches and smaller shall be ASTM A120, black steel pipe. Sizes 4-inches and above shall be standard weight, black, cast iron with screwed fittings, schedule 10 steel piping shall be acceptable when approved by the authority having jurisdiction.
c. Piping Above Grade (Outside): Galvanized Steel
d. Wet Pipe Fittings: Steel fittings shall be ASME B16.9, wrought steel, butt welded. Cast iron fittings shall be ASME 16.1, flanges and flanged fittings. Malleable iron fittings shall be ASME B16.3, threaded fittings.

Mechanical grooved couplings shall be malleable iron housing clamps to engage and lock C shaped elastomeric sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe. Mechanical formed fittings shall be carbon steel housing with integral pipe stop and O-ring and O-ring uniformity compressed into permanent mechanical engagement onto pipe.

e. Dry Pipe Fittings: UL listed for dry pipe service.

f. Victaulic, Grinnell, or approved equal, grooved end fittings and mechanical couplings shall be used for wet pipe and dry pipe systems 2” and larger. Couplings and fitting shall be UL listed and FM approved. Fittings shall be ASTM A536 ductile iron, ASTM A234 forged steel or ASTM A53 fabricated steel with factory grooved ends designed to accept Victaulic couplings.

g. Victaulic, Grinnell, or approved equal, mechanical couplings shall consist of two ASTM A536 ductile iron housings, pressure-responsive, synthetic rubber gasket and plated steel bolts and nuts.

i. Rigid Type: Housings shall be cast with offsetting, angle-pattern bolt pads to provide system rigidity and support and hanging in accordance with NFPA-13. Tongue and recess rigid type couplings shall only be used if the contractor uses a torque wrench for installation. Required torque shall be in accordance with the manufacturer’s latest recommendation.

1) 1-1/4” through 8”: “Installation Ready” stab-on rigid coupling, designed for direct ‘stab’ installation onto grooved end pipe without prior field disassembly and no loose part. Victaulic FireLock EZ Style 009H (1-1/4” – 4”) and Victaulic QuickVic Style 107H (2”-8”).

2) 2” and Larger: Standard rigid coupling design. Victaulic Style 07 Zero-Flex.

ii. Flexible Type: use in seismic areas and where required by NFPA-13.

1) 2” through 8”: “Installation Ready” stab-on flexible coupling, designed for direct ‘stab’ installation onto grooved end pipe without prior field disassembly and no loose parts. Victaulic QuickVic Style 177.

2) 2” and Larger: Standard flexible coupling design. Victaulic Style 75 or 77.

Fire Suppression System Service	Temperature Range	Gasket Recommendation
Freezer Applications	-30°F to 0°F (-34°C to 17°C)	Grade L Silicone FlushSeal® Design
Water/Wet Systems	Ambient	Grade EPDM, Type A-C Shaped, FireLock EZ, or QuickVic Design

h. Gate Valves: 2-1/2 inches & larger - listed 175 lb. OS&Y, flanged. 2 inches & smaller - UL/FM listed 175 lb., bronze, screwed. Furnish all sprinkler control valves with slow close manual operator and position indicator. Tamper switches furnish under Division 21.

i. Grooved End Gate Valves: 2-1/2inches and Larger – UL listed/FM approved, 250 psi maximum pressure rating, OS&Y, ductile iron body, bronze mounted, grooved ends. Victaulic FireLock Series 771.

j. Grooved End Butterfly Valves: 2 inches & Larger: UL listed/FM approved, up to 365 psi maximum pressure rating, ductile iron body, nickel-plated ductile iron disc, Nitrile seat, weather-proof actuator with two pre-wired supervisory switches. Victaulic FireLock Series 765 or Series 705.

k. Globe Valves: 2 inches & smaller - 175 lb., bronze, screwed, UL/FM listed.

l. Check Valves: 2-1/2 inches & smaller - UL/FM listed 175 lb., flanged swing check. 2 inches & smaller - listed 175 lb., bronze swing check, screwed.

m. Grooved End Check Valves: 2 inches and Larger: UL listed/FM approved, up to 365 psi maximum pressure rating, ductile iron body, spring-loaded stainless steel or EPDM coated ductile iron disc, nickel-plated or welded-in nickel seat. Victaulic FireLock Series 717H or Series 717.

n. Finish: All exposed fire suppression piping shall be primed and painted with epoxy red paint. White letters shall indicate pipe and indicate direction of flow. Painting shall be provided under Division 09.

o. Special Requirements: All fire suppression piping, valves, fittings and joints shall comply with applicable National Fire Protection Pamphlets (NFPA) local codes, building codes, Fire Marshal, Owner's Insurance Underwriter, and the authority having jurisdiction.

B. Steel pipe shall be similar and equal to National Allied Tube or Wheatland black or zinc-coated (galvanized) as hereinafter specified. Pipe shall be free from all defects which may affect the durability for the intended use. Each length of pipe shall be stamped with the manufacturer's name.

C. Copper pipe shall be Revere, Anaconda or Chase with approved solder fittings.

D. Welding fittings for steel pipe shall meet the requirements of ASTM Standard A-23 and shall be standard catalog products. Fittings fabricated by metering and notching pipe will not be accepted.

2.2. PIPE HANGERS

A. All hangers for metallic piping shall be adjustable, wrought clevis type, or adjustable malleable split ring swivel type, having rods with machine threads. Hangers shall be Grinnell Company's Figure 260 for pipe ¾-inch and larger, and Figure 65 for pipe 2-inches and smaller, or approved equal. Adjustable pipe stanchion with U-bolt shall be Grinnell Company's Figure 191. Pipe roller supports shall be Grinnell's Figure 181 or Figure 271. Exterior pipe hangers shall be galvanized or stainless steel construction. For copper piping in direct contact with the hanger, hanger construction shall be copper coated to prevent contact of dissimilar metals similar to Grinnell's Figure CT-65. Hanger spacing and rod sizes for steel and copper pipe shall not be less than the following:

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
3/4 & 1	6	5	3/8
1 - ½	6	8	3/8
2	8	8	3/8
2 – ½	10	9	½
3	12	10	½
4	14	12	5/8
5	14	12	5/8
6	16	14	3/4
8	18	16	7/8
10	20	18	7/8
12	20	18	7/8

B. Anchors, guides, and roller supports shall be installed in accordance with the contract drawings and manufacturer's recommendations to provide pipe support and control pipe movement for all piping systems. Anchors and guides shall be securely attached to the pipe support structure. Submit shop drawing for proposed pipe support structure for guides and anchors for approval of the Structural Engineer. Pipe alignment guides shall be Fig. 255 Grinnell, or as approved equal. Guides shall be sized to accommodate the pipe with insulation. Guides shall be steel factory, fabricated, with bolted two section outer cylinder and base for alignment of piping and two section guiding spider for bolting to pipe.

C. Hangers for pipe sizes ½ to 1 ½ inch (13 to 38 mm): Carbon steel, adjustable swivel, split ring, comply with NFPA-13.

D. Hangers for pipe sizes 2 to 4 inches (50 to 100 mm): Carbon steel, adjustable, clevis. Comply with NFPA-13.

E. Hangers for cold pipe sizes 6 inches (150 mm) and over: adjustable steel yoke, cast iron roll, double hanger, comply with NFPA-13.

F. Multiple or Trapeze hangers: Steel channels with welded spacers and hanger rods.

G. Wall support for pipe sizes to 3 inches (76 mm): cast iron hook, comply with NFPA-13.

H. Wall support for pipe sizes 4 inches (100 mm) and over: Welded steel bracket and wrought steel clamp, comply with NFPA-13.

I. Wall support for pipe sizes 6 inches (150 mm) and over: welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll, comply with NFPA-13.

J. Vertical Support: Steel riser clamp, comply with NFPA-13.

K. Floor support for pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support, comply with NFPA-13.

L. Copper pipe support: Carbon steel ring, adjustable, copper plated, comply with NFPA-13.

M. Hanger rods: Mild steel threaded both ends, threaded one end, or continuous threaded, comply with NFPA-13.

N. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

O. Victaulic Style 009H, 107H, and 07, Grinnell, or approved equal, rigid couplings may be used with IPS steel piping systems, which meet the support and hanging requirements of NFPA-13. An adequate number of Victaulic Style 177, 75, and 77, Grinnell, or approved equal, flexible couplings shall also be used to compensate for thermal expansion/contraction of the pipe.

P. For Pipe Hangers installed in corrosive environments such as chemical storage rooms…etc. the same shall be finished with an Electro-Galvanized finish such as Galv-Krom® or approved equal.

2.3. VALVES

A. Provide parts list and assembly drawings (exploded view) for all valves in shop drawing submittals. Provide valves of the same type by the same manufacturer. All valves shall be provided with tamper switches and coordinated with Division 28.

2.4. PRESSURE GAUGES

A. Unless otherwise indicated, pressure gauges shall be the bronze bourdon tube type, 4-1/2-inch dial, stem mounting, cast aluminum adjustable pointer, 1 percent accuracy over middle half of scale range, 1-1/2 percent over balance: Trerice Model 600C; Weksler Instruments, Ernst Gage Co., Miljoco, or as approved equal.

B. Gauges shall have pressure, vacuum, compound, or retard ranges as required, select ranges so that the normal readings are at the approximate midpoint and maximum system pressures do not exceed full scale.

C. Furnish and install a gauge valve at each pressure gauge. Gauge valves shall be Crane Model No. 88, Needle Valve, Ernst Gage Co. FLG 200, Wexler Instrument Corp. Type

BBV4, or approved equal, rated for pressure intended.

D. Gauge connections for pressure gauges or control instruments shall be made using tee fittings, except that gauge connections up to 1-inch size in steel may be using threaded extra heavy pipe couplings welded directly to the main, provided that the main is at least 2-inch size for 2-inch connections, 3-inch size for 3/4-inch connections, and 4-inch size for 1-inch connections. Minimum gauge connection shall be 2-inch ips.

E. Provide snubbers on all gauges. Snubbers shall be No. 872 by Trerice, RS1/RS6 by Wexler Instruments, Miljoco or as approved equal.

2.5. PIPING SPECIALTIES

A. Furnish and install flexible pipe connections, as specified and/or shown on the drawings, at suction and discharge connections of all base mounted and vertical in-line pumps, and all vibrating equipment and elsewhere as shown. Refer to Division 23 Section, Vibration Control for HVAC, Plumbing and Fire Protection Equipment for specifications.

B. Victaulic Style 177, 75, or 77, Grinnell, or approved equal, flexible couplings may be used in lieu of flexible connectors for vibration isolation at equipment connections. Three (3) couplings, for each connector, shall be placed in close proximity to the source of vibration.

2.6. ESCUTCHEONS

A. Provide chromium plated escutcheons properly fitted and secured with set screws on all exposed piping which passes through walls, floors or ceilings of finished spaces.

B. All escutcheon plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface. Plastic escutcheon plates will not be accepted.

2.7. DIELECTRIC CONNECTIONS:

A. Furnish and install electrically insulated dielectric waterway fittings, unions or flanges, as manufactured by EPCO Sales, Inc., or Victaulic Co. at the following locations:

1. Where steel piping systems join copper piping.
2. Avoid the installation of steel nipples, cast iron or steel valves and specialties, or other ferrous components in predominately copper piping systems. Where such installation is necessary, isolate the component with dielectric connections. Do not mix steel pipe and copper tube in the same run of pipe or in the same section of a piping system.

2.8. SLEEVES

A. Sleeves shall be provided around all pipes through walls, floors, ceilings, partitions, roof structure members or other building parts. Sleeves shall be standard weight galvanized iron pipe two sizes larger than the pipe or insulation so that pipe or insulation shall pass through masonry or concrete walls or floors. Provide 20 gauge galvanized steel sheet or galvanized pipe sleeves for all piping passing through frame walls.

B. Sleeves through floors shall be flush with the floor except for sleeves passing through

Equipment Rooms which shall extend ¾-inch above the floor. Space between the pipe and sleeve shall be caulked. Escutcheon plates shall be constructed to conceal the ends of sleeves. Each trade shall be responsible for drilling existing floors and walls for necessary sleeve holes. Drilling methods and tools shall be as hereinbefore specified.

C. Sleeves through walls and floors shall be sealed with with a waterproof caulking compound.

D. Firestop at sleeves that penetrate smoke barriers smoke partitions and/or rated walls/floors.

2.9. WATER PROOF PIPE PENETRATION SEALS

A. Provide and install waterproof pipe penetration seals at all pipes that enter the building below grade or through exterior wall.

B. Link seals are to be Metraflex Metraseals, Model MS, Linkseal, or approved equal, black EPDM seal material, glass reinforced plastic pressure plates, zinc plated nuts and bolts, seals are to be resistant to sunlight and ozone, pressure rated to make a hydrostatic seal of up to 20 psig and up to 40 feet of head, temperature rated from –40 degrees F to 250 degrees F.

PART 3. EXECUTION

3.1. GENERAL PIPING INSTALLATION REQUIREMENTS

A. All pipes shall be cut accurately to measurements established at the building, and shall be worked into place without springing or forcing, properly clearing all windows, doors and other openings. Excessive cutting or other weakening of the building structure to facilitate piping installation will not be permitted. All pipes shall be so installed as to permit free expansion and contraction without causing damage. All open ends of pipe lines, equipment, etc., shall be properly capped or plugged during installation to keep dirt or other foreign material out of the system. All pipes shall be run parallel with the lines of the building and as close to walls, columns and ceilings as may be practical, with proper pitch. All piping shall be arranged so as not to interfere with removal of other equipment or devices and not to block access to doors, windows, manholes, or other access openings. Flanges or unions, as applicable for the type of piping specified, shall be provided in the piping at connections to all items of equipment, and installed so that there will be no interference with the installation of the equipment. All valves and specialties shall be placed to permit easy operation and access and all valves shall be regulated, packed and glands adjusted at the completion of the work before final acceptance. All piping shall be installed so as to avoid air or liquid pockets throughout the work. Ends of pipe shall be reamed so as to remove all burrs.

B. All piping shall be run to provide a minimum clearance of 2-inches between finished covering on such piping and all adjacent work. Group piping wherever practical at common elevations.

C. All valves and other fittings shall be readily accessible.

D. Drain valves with hose connections shall be provided at low points for drainage of piping systems. Blow down valves shall be provided at the ends of all mains and branches so as to properly clean by blowing down the lines throughout in the direction of normal flow.

E. Spring clamp plates (escutcheons) shall be provided where pipes are exposed in the building and run through walls, floors, or ceilings. Plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface.

F. Install all valves with stem upright or horizontal, not inverted.

G. Where pipe support members are welded to structural building framing, scrape, brush clean, weld and apply one coat of zinc rich primer.

H. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

I. All water containing pipes shall be routed clear of combustion air dampers and louvers to prevent freezing condition when dampers are open.

J. Where zone valve assemblies are installed in stairwells, install primed and painted 18 gauge removable mesh screen. Color of paint shall be as selected by Architect.

3.2. PRESSURE GAGE INSTALLATION REQUIREMENTS.

A. Install pressure gages in piping tees with pressure-gage valve located on a pipe at most readable location.

B. Adjust faces of pressure gauges to proper angle for best visibility.

C. Clean windows of gages and clean factory-finished surfaces. Replace cracked and broken window, and repair scratched and marred surfaces with manufacturer's touch up paint.

3.3. VALVE INSTALLATION REQUIREMENTS

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until 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 from fully open to fully closed positions. Examine guides and seats made accessible by such operation.

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. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

G. Install valves as indicated, according to manufacturer's written instructions.

H. Piping installation requirements are specified in other Division 21 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

I. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.

J. Locate valves for easy access and provide separate support where necessary.

K. Install valves in horizontal piping with stem at or above the center of the pipe.

L. Install valves in a position to allow full stem movement.

M. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.

3.4. PIPE JOINTS INSTALLATION REQUIREMENTS

A. Screwed Joints: All screwed joints shall be made with tapered threads properly cut. Screwed joints shall be made perfectly tight with a stiff mixture of graphite and oil, applied with a brush to the male threads on the fittings.

B. Grooved Joints: Install in accordance with the manufacturer's (Victaulic, Grinnell, or approved equal) guidelines and recommendations. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be molded and produced by Victaulic. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing. A Victaulic factory-trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

C. Soldered Joints and Copper Piping: Joints in copper piping shall conform to the following minimum standards.

1. The pipes shall be cut to a length making certain that the ends are square, using a fins hacksaw blade or tube cutter. The ends of all pipes shall be reamed and all burrs removed.
2. The outside end of the pipe and the cut end of the fitting shall be cleaned with steel wool, sand cloth, or steel wire brush. All dark spots shall be removed.
3. The flux shall be applied evenly and sparingly to the outside end of the pipe and the inside of the outer end of the fitting until all surfaces to be jointed are completely covered. The piping and fitting shall be slipped together and reworked several times to insure an even distribution of the flux.
4. The correct amount of solder per joint for each size pipe shall be used in accordance with the manufacturer's recommendations.
5. Solder joints shall be made by using a direct flame from a torch.

6. On pipe sizes larger than ¼-inch, the fittings and valves in the pipe shall be moved or tapped with a hammer when the solder starts to melt to insure an even distribution of the solder.
7. The excess solder shall be removed while it is still in the plastic state leaving a fillet around the cup of the fitting.
8. Solder joints shall be suitable for working pressure of 100 psig and for working temperature of not less than 250 degrees F. The type of solder and flux used will be submitted for approval. Type 95-5 shall be the minimum standard.

D. Where copper piping joins steel piping, approved bronze adapters shall be used.

E. Prohibited Connections: No direct weld, soldered, or brazed connections, without unions or flanges, shall be made to valves, strainers, apparatus, or related equipment. Right and left couplings, long threads, or caulking of pipe threads or gasket joints will not be permitted.

3.5. HANGERS AND SUPPORTS INSTALLATION REQUIREMENTS

A. General: All hangers shall be of an approved type arranged to maintain the required grading and pitching of lines to prevent vibration and to provide for expansion and contraction. Saddles shall be Grinnells Figure 173/273 or approved equal. Provide approved spacers between saddles and pipe where flexible insulation is specified. Provide insulation protection shields for insulated piping without saddles. Shield shall be Grinnell Figure 167 or as approved equal. Comply with NFPA-13.

B. Spacing: Regardless of spacing, hangers shall be provided at or near all changes in direction, both vertical and horizontal, for all piping.

C. Vertical Lines: Shall be supported at their bases, using either a suitable hanger placed in a horizontal line near the riser, or a base type fitting set on a pedestal, foundation or support. All vertical lines extending through more than one floor level shall be supported at each floor with a riser clamp. Riser clamp shall be Grinnell Co.'s Figure 261, or approved equal. All vertical drops to pump suction elbows shall be supported by floor posts.

D. Racks and Brackets: All horizontal piping on vertical walls shall be properly supported by suitable racks securely anchored into the wall construction. Where not practical to obtain ceiling anchorage, all piping near walls shall be supported by approved brackets securely anchored into the wall construction. Washer plates (Fib. 60, 60L) and other miscellaneous attachments, fasteners, etc., shall be Grinnell or as approved equal. All exterior hanger and bracket systems in their entirety shall be galvanized.

E. Pipe Hangers and supports shall be attached to the panel point at the top chord of bar joist or at a location approved by the structural engineer.

F. Select hangers and components for loads imposed. Secure rods with double nuts.

G. Support of horizontal piping shall allow for vertical adjustment after installation of piping.

H. Support overhead piping with clevis hangers.

I. Do not support all parallel piping from the same joist. Stagger all supports in accordance with the structural engineer's recommendations.

J. 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.

K. Construct concrete anchors of poured in place concrete of dimensions indicated and include embedded fasteners.

L. Refer to structural documents for appropriate connection/attachment materials to building.

M. Fire protection pipes shall be supported independently of other building trade supports per NFPA-13.

3.6. PIPING IDENTIFICATION INSTALLATION REQUIREMENTS

A. All piping shall be identified with painted background marked with the name of the service with arrows to indicate flow direction. Color code and system identification shall comply with ANSI Standards and piping identification system shall comply with ASME A13.1-81., scheme for the identification of piping systems and NFPA pamphlets, latest edition.

B. Markings shall be plain block letters, stenciled on pipes, and shall be located near each branch connection, near each valve, and at least every 10 feet on straight runs of pipe. Where pipes are adjacent to each other, markings shall be neatly lined up. All markings shall be located in such manner as to be easily legible from the floor. Pipe identification schedule shall be as follows:

OUTSIDE DIAMETER OF PIPE OR COVERING (INCHES)	LENGTH OF COLOR FIELD (INCHES)	SIZE OF LETTERS (INCHES)
½ to 1 ¼	8	½
1-½ to 2	8	¾
2 ½ to 6	12	1 ¼
8 to 10	24	2 ½
Over 10	32	3 ½

3.7. VALVE IDENTIFICATION REQUIREMENTS

A. All valves shall be tagged with a numbered tag.

B. The tags shall be made of 1-inch diameter brass tags fastened to the valve by means of brass chains. Numbers shall agree with valve numbers on diagrammatic herein before specified.

C. Provide a minimum of six (6) valve charts with valve numbers indicating valve type, size, manufacturer and service.

D. Additional valve charts shall be mounted behind glazed wooden frames and be hung in the main fire protection riser room. Additional copies shall be provided in each copy of the O&M manuals.

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WATER BASED FIRE SUPPRESSION SYSTEM – FIRE PUMP
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SECTION 21 10 00 - WATER BASED FIRE SUPPRESSION SYSTEM – FIRE PUMP

PART 1. GENERAL

1.1. REFERENCE

A. The conditions of the Contract and General Requirements apply to the work specified in this section. All work under this section shall also be subject to the requirements of Division 21 Section, Common Work Results for Fire Protection Systems and Division 01 General Requirements.

B. Submit complete shop drawings of all equipment utilized with the fire pump in accordance with Division 21 Section, Common Work Results for Fire Protection. Submittals shall include but not be limited to the following fire pump system and accessories:

1. Alarm Check Valves
2. Alarm Gong
3. Automatic Air Release
4. Automatic Air Release Valves
5. Automatic Fire Pump Controller with integral transfer switch
6. Automatic Jockey Pump Controller
7. Backflow Preventers
8. Ball Drip Valves
9. Blind Flange with Escutcheon
10. Circulation Relief Valve
11. Eccentric Reducers
12. Fire Department Connection
13. Fire Pump and Associated Trim
14. Flow Meters
15. Flow Switches
16. Hose Header Valves and Accessories
17. Hose Valve Cabinets
18. Inspector’s Test Station
19. Jockey Pump and Associated Trim
20. Pressure Sensing Devices, Valves
21. Pressure Switches
22. Pressure/Vacuum Gauges
23. Relief Valves
24. Standpipe Valves
25. Tamper Switches
26. Valves and Piping

C. Provide fire pumps and associated equipment complete and ready for operation. Equipment materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with NFPA-13, NFPA-70, NFPA-14, and NFPA-72E. Devices and equipment for fire protection service shall be U.L listed or FM approved.

D. All of the fire pump equipment and devices shall be included within the project Operations and Maintenance Manuals.

E. Refer to Division 21 Section, Fire Protection Pipes, Fittings, and Valves.

F. Fire Protection Systems design, equipment and installation shall comply with the Delaware State Fire Prevention Regulations, latest edition including all Annexes and Addendums.

1.2. DESCRIPTION

A. Provide all facilities, labor, materials, tools, equipment, appliances, transportation, supervision, and related work necessary to complete the work specified in this Section and as shown on the drawings. The work shall be performed by a licensed sprinkler contractor only. All equipment, piping, devices, and valves shall be sized based on hydraulic calculations. Include a 10 psig safety factor with hydraulic calculations.

B. Layout sprinkler system complete and size all fire protection piping in accordance with requirements of the National Fire Protection Association and the State Fire Marshal. System shall be designed for occupancy as required by applicable codes. Conceal fire protection piping in finished spaces unless indicated otherwise. System drains and inspector's test shall not be located in finished spaces.

C. Sprinkler equipment and work shall conform to requirements of National Fire Protection Association Standard No. 13, No.14, No. 20, No. 24, and No. 101. In addition, all work shall conform to requirements of all codes and regulations of authorities having jurisdiction over this work, including, but not limited to, State Fire Marshal, County Fire Marshal, Life Safety Codes and International Code, and Insurance Underwriter.

D. Preliminary Shop Drawing: Prior to preparing detailed working drawings for submission to State Fire Marshal, submit preliminary sprinkler system layout to the Architect for review and approval. Show all finished ceilings, light fixtures, air diffusers and other ceiling mounted devices. Coordinate sprinkler head types and locations with ceiling types. All sprinkler heads in acoustic tile ceilings shall be centered in the tile.

E. The fire protection contractor shall prepare dimensioned and detailed working drawings, specifications, and hydraulic calculations and submit same to the State Fire Marshal and/or County Fire Marshal for review and approval. Prior to submission to the Fire Marshal, the Fire Protection Contractor shall have all fire protection drawings, submittals, calculations reviewed and approved by a registered Fire Protection Engineer or a level III Nicet Technician. One set of these approved documents shall be provided to the Engineer for record purposes. All costs related to changes required to obtain the Fire Marshal's or Insurance Underwriters' approval shall be the responsibility of the contractor.

F. Manufactured equipment and materials shall be submitted to the Engineer for review and approval, in accordance with the requirements of Division 21 Section, Common Work Results for Fire Protection.

G. Hydraulic calculations should be based on an available water supply as follows:

Static Pressure =	44 psig
Residual Pressure =	34 psig

Flow =	1300 GPM
Existing Pipe Material	For Hydraulic Calculations Assume Roughness Coefficient C factor = 100 for all Exterior Piping.

H. Hydraulic calculations shall include a 10 psig safety factor to account for pipe aging and deterioration of water supply.

I. The fire pump size (flow and pressure) shall be hydraulically determined per the requirements of NFPA-13.

J. The fire pump room shall be fully sprinklered in accordance with NFPA-13 and NFPA-20. Provide sprinkler heads with guards, inspectors test station, drains and piping to completely protect pump room.

K. For areas subject to freezing (exterior canopy, covered porch, etc.), Contractor shall provide and install dry pipe heads, piping, control valves, tamper switches, test stations, dry pipe value, air compressors, and accessories, etc., required by NFPA-13 and the authority having jurisdiction. For small loops, antifreeze may be utilized if allowed by the authority having jurisdiction. Install piping, control valves, tamper switches, test stations, backflow preventers, antifreeze expansion tanks, fill cup, drain valve, etc. as required by NFPA-13 and the authority having jurisdiction.

L. Where combustible construction/materials are located above ceilings, provide above ceiling fire protection in accordance with N.F.P.A.-13.

1.3. DELIVERY, STORAGE AND PROTECTION

A. Refer to Division 01 Section, General Requirements: Transport, handle, store, and protect products.

B. Accept fire pumps and components on site in factory packing. Inspect for damage. Comply with manufacturer's rigging and installation instructions for all pumps, drives, and equipment.

C. Protect fire pumps and components from physical damage including effects of weather, water, and construction debris.

D. Provide temporary inlet and outlet caps, and maintain in place until installation.

1.4. EXTRA MATERIALS

A. Provide one set of seals for each pump type and model supplied.

B. Provide extra sprinklers under provisions of NFPA-13. Provide suitable wrenches for each sprinkler type and metal storage cabinet.

1.5. PERMITS FROM THE AUTHORITY HAVING JURISDICTION AND FEES

A. Pay all permits, fees, and charges required for this work.

1.6. HYDRANT FLOW TESTS

A. The Fire Protection Contractor shall perform a hydrant flow test.

B. The hydrant flow test shall be performed by the Fire Protection Contractor in the vicinity of each building at no additional cost to the Owner. Hydrant flow test shall be completed not more than 12 months prior to submission of the working plans.

C. Where practical, tests shall be performed between 9:00 a.m. and 5:00 p.m. on a normal working day during summer. If conducting the test is impractical during these hours, then a local Fire Department representative shall be present to observe the test during off peak hours and to acknowledge the correctness of results.

D. The tests shall be submitted for review prior to submitting any hydraulic calculations. The test data shall contain the following:

1. Date of the test
2. Who performed the test and who was present.
3. Site plan indicating locations and diameters of water mains and locations of the hydrants tests.
4. Grade elevation of the hydrant tests
5. Static pressure in psig
6. Flow in GPM
7. Residual pressure in psig
8. Hydrant butt size in inches
9. Hydrant coefficient

1.7. ALTERNATES

A. Refer to Division 01 Section, Alternates - Alternates for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. SPECIALTIES

A. All sprinkler heads shall be U.L. listed and shall be of the same manufacturer throughout the building.

B. Piping shall be in accordance with Division 21 Section, Fire Suppression System Piping, Fittings, Valves, etc. All exposed fire protection piping in unfinished areas shall be painted with red epoxy paint. White letters shall identify piping and indicate direction of flow. Exposed fire protection piping within finished areas shall be painted in color as determined by the Architect/Engineer.

C. Shut-off valves shall be UL approved O.S. and Y. double disc gate valves or UL/FM approved grooved end butterfly valves.

D. Check valves shall be swing check type or spring-loaded type UL approved for the application.

E. Fire department connection shall be Potter-Roemer 5750 Series, Elkhart, American Fire Hose, Guardian, American Fire House & Cabinet, Elkhart Brass Mfg Co, Fire Protection Products, or approved equal, with individual drop clapper valves, plugs, and chains on each connection. Exposed parts shall be polished chrome plated. Threads shall match local Fire Department specifications. Where required by local Fire Department, provide Storz type Siamese connection. Escutcheon shall be lettered or AUTO SPRINKLER - STANDPIPE, as required. Locate as shown on drawings and connect to main fire line through check valve with ball drip. Discharge ball drip drain line as indicated on contract drawings. Type of fire department connection shall be determined by local fire department.

F. Coordinate the fire protection systems with the fire alarm system specified under Division 26. Provide alarm initiating devices with proper contact arrangement. All electrical wiring shall be furnished and installed under Division 26.

G. Flow control valve, alarm switches and valve supervision shall be furnished and installed under this Division. All wiring shall be accomplished by the electrical contractor, under Division 26. Provide any additional flow control valves, alarm switches, tamper switches and flow switches required by NFPA-13, but not indicated on contract drawings. Coordinate with the alarm system and electrical subcontractor.

H. Pipe and fittings shall meet the requirements of NFPA 13, NFPA-20, and NFPA-24.

I. Wet pipe alarm check valve shall be Victaulic FireLock Series 751, Reliable Automatic Sprinkler Co., Tyco Fire Products, or approved equal. Valve shall be UL listed and FM approved for sprinkler systems with 300 psig maximum working pressure. Provide complete valve trim package including all necessary valves, gauges, fittings, nipples and alarm test. Valve internal components shall be replaceable without removing the valve from the installed position. Valve shall be installed in the vertical position only.

J. Retard Chamber shall be Victaulic Series 752. Retard Chamber shall be UL listed and FM approved. Chamber shall prevent false alarms with ordinary city water pressure surges.

K. Water motor alarm shall be Victaulic Series 760, Globe Fire Sprinkler Corp., Tyco Fire Products, Viking Corp., or approved equal. Alarm shall be UL listed and FM approved. Alarm shall be hydraulically driven and tested 100 percent at low flow, 5 psig. Gong assembly and motor housing shall be finished with corrosion resistant, red enamel. Furnish unit with nylon bearings and inlet strainer. At contractor's option furnish and install electric gong. Install all power and control wiring under this Division of specifications.

2.2. SPRINKLER HEADS

A. Suspended Ceiling:

1. Manufacturer: Victaulic, Viking, Grinnell, Reliable, or approved equal.
2. Sprinkler heads installed in suspended ceilings and drywall ceilings including bulkheads, shall be Victaulic Model V38 concealed response sprinkler or approved equal. Cover plate shall be finished with a polyester baked enamel finish. Color selection of cover plates shall be by the Architect. Submit color chart to Architect for color selection. Provide cover assembly with each head. Frangible glass bulb

shall be temperature rated for specific area hazard.

3. Sprinkler heads in all other areas with finished ceilings shall be Victaulic Model V27, or approved equal. These sprinkler shall be standard pendant type with matching screw on escutcheon plate. Sprinkler and escutcheon plate finish shall be chrome plated. Fusible link shall be temperature rated for specific area hazard.

B. Exposed Area Type:

1. Manufacturers: Victaulic, Viking, Grinnell, Reliable, Gem or approved equal.
2. Sprinkler heads in unfinished or exposed areas without ceilings shall be Victaulic Model V27, or approved equal. These sprinklers shall be standard, ½ inch upright, pendant or conventional where required. Provide guards where hereinafter indicated. Sprinklers shall be brass with frangible glass bulb temperature rated for specific area hazard. Provide standard brass, screw on flat escutcheon plate.

C. Sidewall type:

1. Manufacturers: Viking, Grinnell, Reliable, Gem, or approved equal.
2. Sidewall sprinklers shall be quick response concealed horizontal sidewall type with matching cover plate. Sprinkler and escutcheon plate finish shall be custom color as selected by Architect. Fusible link shall be temperature rated for specific area hazard.

D. Dry Sprinklers:

1. Manufacturers: Victaulic, Viking, Grinnell, Reliable, Gem or approved equal.
2. Sprinkler heads for areas subject to freezing (walk-in boxes), small loading docks, and similar spaces shall be Victaulic Model V36 dry sprinkler or approved equal. Dry sprinkler shall be standard or expose pendant type with matching escutcheon plate. Sprinkler and escutcheon plate shall be chrome plated. Frangible glass bulb shall be temperature rated for specific area hazard. Length of heads shall be as required to suit field conditions. Provide adjustable surface mounted escutcheon plate with each head. Provide flush ceiling plate.

E. Quick Response Type:

1. Manufacturers: Victaulic, Viking, Grinnell, Reliable, or approved equal.
2. Sprinkler heads for shall be listed quick response sprinklers in accordance with NFPA-13 and NFPA-101. Quick response sprinklers shall be Victaulic Model V27 or approved equal. Model and deflector style shall be as required to accommodate upright, pendant, sidewall or recessed mounting. Sprinklers and escutcheon plates shall be chrome plated. Frangible glass bulb shall be temperature rated for specific area hazard.

F. The temperature rating of the sprinklers shall be as required by N.F.P.A.-13 and or the authority having jurisdiction.

G. All sprinkler heads installed in lay-in ceiling tiles shall be located in the center of the tile to provide a symmetrical, aesthetic and neat appearance. All sprinkler heads installed in bulkheads, recesses, and soffits shall be centered to provide a symmetrical, aesthetic and neat appearance.

H. Provide extended escutcheons in rooms with surface mounted lighting fixtures.

I. Additional heads shall be furnished as required by NFPA-13. The heads shall be in a cabinet designed to hold the heads and include one sprinkler head wrench for each type of sprinkler. Cabinet shall be mounted where indicated in the field.

J. Head guards shall be provided in mechanical spaces, penthouses, janitors' closets, electrical rooms, fire pump rooms, auxiliary gymnasiums, gymnasiums, storage areas, elevator shafts, and elevator machine rooms. Finish for head guards in finished spaces shall be selected by the Architect.

K. Sprinkler escutcheons and guards shall be listed, supplied, and approved for use with the sprinkler, by the sprinkler manufacturer.

L. Provide high temperature sprinkler heads for use adjacent to kilns, skylights, autoclaves, heaters, lights, or other high temperature areas.

M. All sprinklers, piping, and pipe hangers installed in corrosive areas (locker rooms, chemical room…etc.) shall be provided with a protective coating.

2.3. FLEXIBLE SPRINKLER DROPS

A. Stainless Steel Sprinkler Fittings

1. Manufacturer: Victaulic VicFlex® or Grinnel.
2. In lieu of rigid pipe offsets for concealed locations only, or return bend for sprinkler drops, the Victaulic VicFlex® stainless steel, multiple-use, sprinkler fitting system may be used to locate sprinklers as required by final finished ceiling tiles and walls. The drop system shall consist of a braided or unbraided (corrugated) type 304 stainless steel flexible tube, a zinc-plated steel 1" NPT male threaded nipple for connection to branch-line piping, and a zinc-plated steel reducer with ½" or ¾" NPT female thread for connection to the sprinkler head. Union joints shall be provided for ease of installation. The flexible drop shall attach to the ceiling grid using a one-piece open gate bracket. The braided drop system is FM approved for sprinkler services to 200 psi and can be installed without the use of tools, and the unbraided system is UL listed for sprinkler services to 175 psi.

2.4. SIGNS

A. Provide 9 inch x 7 inch signs suspended from control valves which indicate the purpose of the valve and its normal position, Central Type A or approved equal.

B. All control, drain, and test connection valves shall be provided with signs indicating purpose.

C. Signs shall be fabricated of an approved material, painted red with white lettering.

D. Sign shall have typed labels. Hand written labels shall not be acceptable.

2.5. DRAINS

A. The sprinkler systems shall be arranged to be completely drainable. Means of drainage shall be provided with adequate protection from freezing.

B. Drain valve may be combined with sprinkler alarm test valve and sight glass, G/J Innovations Sure-Test, Reliable Automatic Sprinkler Co., Tyco Fire Products, Victaulic, or approved equal. Valve shall be UL listed with positive off handle for off, test or drain, integral sight glass, orifice size equal to smallest sprinkler orifice and full 1 inch drain.

2.6. ALARM DEVICES

A. Approved water flow switches shall be installed to activate the fire alarm, and annunciate sprinkler flow at a minimum on each floor, each system riser, elevator shaft where indicated on the contract drawings and where required by NFPA or the authority having jurisdiction. Conductors shall be provided under the electric division to provide fire alarm, and annunciation. Activation of the sprinkler system by one sprinkler or equivalent test shall cause the fire alarm system to activate, and the appropriate lamp(s) to activate on the annunciator. An approved test shall be provided for each water flow switch.

B. All valves controlling water supply for sprinklers shall be electrically supervised in accordance with requirements of NFPA 13 and 72A, and provided under this Division. Provide separate valve chart for all fire protection valve indicating valve type, normal position, size, location and type of supervision insert in O&M manual and mount additional copies in fire pump room and mechanical rooms.

C. Valve tamper switches shall be Model OSY2 as manufactured by System Sensor or Model OSYSU-A2 as manufactured by Potter Electric Signal Company or approved equal. The valve tamper switches shall monitor the open position of all OS&Y gate valves. Each tamper switches shall contain two sets of single pole double throw, Form C contacts. All valve tamper switches shall have tamper resistant covers that upon removal of the cover will cause the switches to operate. Tamper switches shall be suitable for 125/250 VAC @ 15 AMPS. All tamper switches shall be U.L. listed and F.M. approved.

D. Pressure type flow switches shall be Model EPS 10 as manufactured by System Sensor or Model PS10-2 as manufactured by Potter Electric Signal Company, Tyco Fire Products, United Electric Controls, Viking Corp., or approved equal. Each pressure type flow switch shall contain two sets of single pole double throw switch contacts. All pressure type flow switches shall have tamper resistant covers that upon removal of the cover will cause the switches to operate. Pressure type flow switches shall be suitable for 125/250 VAC @ 10 AMPS. All pressure type flow switches shall be U.L. listed and F.M. approved.

E. Vane Type waterflow switch with retard shall be WFD Series as manufactured by System Sensor or Model VSR-F as manufactured by Potter Electric Signal Company, ADT Security Services, McDonnell & Miller, Viking Corp., Watts, or approved equal. The VAC type waterflow switches shall contain two single pole, double throw form C, snap return switches. All Vane type waterflow switches shall have tamper resistant covers that upon removal of the cover will cause the switches to operate. Vane type waterflow switches shall be suitable for 125/250 "AC" 10 AMPS. All vane type waterflow switches shall be U.L. listed and F.M. approved.

2.7. GAUGES

A. A listed 3 ½ inch dial spring pressure gauge shall be connected to the top of each standpipe. Gauges shall be located in a suitable place to prevent freezing. Each gauge shall be controlled by a valve having arrangement for draining.

B. Listed pressure gauges with connections not smaller than ¼ inch shall be installed at the system main drain, at each main drain associated with a floor control valve, and above and below each alarm check-valve.

C. All pressure gauges shall be listed and shall have a maximum limit not less than twice the normal working pressure at the point where installed. They shall be installed to permit removal and shall be located where they will not be subject to freezing.

D. (Discharge Gauge on Fire Pump) A pressure gauge having a dial not less than 3 ½ inches in diameter shall be connected near the discharge casing with a ¼ inch gauge valve. The dial shall indicate pressure to at least twice the rated working pressure of the pump but not less than 200 psi. The face of the dial shall read in pounds per square inch with the manufacturers standard graduations. ITT A-C Pump or approved equal.

E. (Suction Gauge on Fire Pump) A compound pressure and vacuum gauge having a dial not less than 3 ½ inches in diameter shall be connected to the suction pipe near the pump with a ¼ inch gauge valve. The face of the dial shall read in inches of mercury for the suction range. The compound gauge shall have a pressure range two times the rated maximum suction pressure of the pump, but not less than 100 psi. Compound gauges shall be ITT A-C Pump or approved equal.

2.8. DOUBLE DETECTOR CHECK VALVE BACKFLOW PREVENTER (FIRE PROTECTION SYSTEM)

A. The sprinkler system backflow preventer shall be provided under this Division and coordinated with Plumbing Contractor. Backflow preventer shall be sized for sprinkler demand to limit pressure drop to 5 psig.

B. Backflow preventers for Fire Protection Systems shall be ASSE/AWWA-1015 approved, double detector check-valve backflow preventer assemblies at sprinkler system water service connections. Units shall be specifically listed for Fire Protection use. Units shall be double detector check valve as manufactured by Watts 709 DCDA, Ames, Conbraco, Wilkens, or approved equal with OS&Y Gate valves, U.L. listed, F.M. approved, NSF-61 approved. Units shall be suitable for minimum 175 psi working pressure. Backflow preventers shall be factory tested at two (2) times the working pressure encountered or as required by N.F.P.A. Backflow preventer shall be capable of withstanding test pressures per N.F.P.A.

C. Backflow preventer shall be factory finished with epoxy coated paint or shall be 304 stainless steel.

D. Pipe any discharge openings full size, through air gap fittings, to nearest floor drain. Maintain clearances for servicing as required by Plumbing Code and authority having jurisdiction. Discharge piping shall be Type L copper pipe.

E. Provide and install tamper switches on all backflow preventers OS&Y gate valves. Backflow preventer shall be installed between 12 inches and 60 inches above finished floor. Provide 18 inch clearance around backflow preventer for service and maintenance.

F. Unit shall include auxiliary piping with approval backflow preventer and water meter. Meter shall indicate flow in gallons per minute.

2.9. VERTICAL IN-LINE ELECTRIC FIRE PUMP

A. Furnish and install where indicated on the drawings ITT A-C, Peerless, Allis Chalmers, Aurora or approved equal, electric driven, vertical in-line, close coupled fire pump. The complete pumping unit shall be listed by Underwriters Laboratories, Inc. The entire pumping unit shall meet all requirements of National Fire Protection Association Pamphlet No. 20.

B. The fire pump shall be designed to deliver the design flow with a total boost as determined by hydraulic calculations per NFPA-13 and NFPA-20. The Fire Pump Suction Piping shall be sized for minimum resistance to flow. Suction piping from street to fire pump shall be sized to prevent suction pressure at pump from dropping below 10 psig, when tested at 150 percent of nominal capacity. Pump suction piping size shall be as indicated on contract drawings or as required by NFPA-20, whichever is the larger of the two requirements.

C. Type: UL 448 and UL 778 vertical, single stage, close coupled, direct connected, radially split casing, for 250 psi (1,720 kPa) maximum working pressure.

D. Casing: Cast or ductile iron, with suction and discharge gage ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.

E. Impeller: Bronze, fully enclosed, balanced and keyed to shaft.

F. Shaft: Alloy steel with replaceable bronze shaft sleeve.

G. Seal: Packing gland with minimum four rings graphite impregnated packing and bronze lantern rings, 230 degrees F (110 degrees C) maximum continuous operating temperature.

H. Electrical characteristics shall be as indicated on contract drawings. Motor horsepower shall not exceed scheduled capacity. Motors shall be U.L. listed.

2.10. FIRE PUMP CONTROLLER

A. Furnish and install for each fire pump, a Joslyn Clark or approved equal fire pump controller. Fire pump controller shall be service entrance rated, Wye-Delta Type, Closed Transition as manufactured by Joslyn Clark or approved equal.

B. The fire pump controller shall be listed by Underwriters Laboratories and approved by Factory Mutual. The entire fire pump controller and accessories shall meet all requirements of National Fire Protection Association Pamphlet No. 20.

C. The Wye Delta type reduced voltage starting method shall minimize inrush current. The starters shall be closed transition type in which the motor circuit is closed during the transition from start to run. Under a normal automatic start mode, the start contactors shall close connecting the motor to line in a wye connection. After approximately a 3 second time delay, the start contactors shall open and the run contactors shall close reconnecting the motor in a delta connection. During the transition, a contactor connects a resistor bank to keep the motor partially energized.

D. The starting line current shall be reduced to 33.3 percent of across-the-line starting in rush and starting torque shall be approximately 33.3 percent of normal starting torque.

E. The following standard equipment and performance features shall be provided with the fire pump controller:

1. Disconnect Switch. Externally operable, quick break type.
2. Circuit breaker; size to NFPA-20, minimum 65,000 amperes interrupting capacity.
3. Neutral terminal lug(s).
4. Grounding/bonding terminal lug(s).
5. Automatic start responsive to a change in water pressure.
6. Automatic stop with running period timer.
7. Terminal board jumper provided for manual stop operation.
8. Emergency start, by simply lifting the mechanical start handle.
9. Locked rotor protection for drive motor protection.
10. Voltage surge protection.
11. Motor starter: Energized automatically through pressure switch or manually by external operable handle.
12. Pressure Switch.
13. Pilot lamp: Indicate circuit breaker closed and power available.
14. Test Accessories: Ammeter test link and voltmeter test studs.
15. Alarm Relay: Energizes alarm to indicate circuit breaker open or power failure.
16. Switch Relay: For remote start.
17. Manual Selection Station: On enclosure marked "Automatic" and "Non-Automatic".
18. Pressure recorder that shall operate for at least 7 days without resetting or rewinding.
19. Integral service entrance rated automatic transfer switch.
20. Stainless steel pressure transducer.

F. The fire pump controller shall be constructed of heavy gauge formed steel, Type 2 enclosure with top dry hood and baked enamel red finish. The fire pump controller shall be mounted on leg supports and 4 inch high housekeeping pad.

G. The following contactors for remote alarm shall be provided within the fire pump controller:

1. Pump running
2. Loss of line power in any phase
3. Phase reversal
4. Generator power provided

H. The fire pump controller shall be capable of and designed for operation at scheduled horsepower, voltage, and phase. The exact size of the fire pump controller shall be coordinated with the size of the fire pump. The fire pump controller shall be service entrance rated.

2.11. JOCKEY PUMP (PRESSURE MAINTENANCE PUMP)

A. Furnish and install where indicated on the drawings one ITT-A-C, horizontal close coupled, regenerative turbine jockey pump. Jockey pump shall be capable of flowing a minimum flow of 5 GPM at a total dynamic head as determined by N.F.P.A.-20.

B. The entire jockey pump shall meet all requirements of National Fire Protection Association Pamphlet No. 20. Provide relief valve for jockey pump where required by N.F.P.A.-20.

C. Jockey pump shall be all bronze fitted with 303 stainless steel shaft and BUNA N "C" rings.

D. Electrical characteristics shall be as indicated on the contract drawings. Motor horsepower shall not exceed scheduled capacity.

E. Mount jockey pump on 4 inch high, concrete housekeeping pad.

F. Control of automatic jockey pump controller with full voltage starter and minimum run timer to start pump on pressure drop in system and stay in operation for minimum period of time. Fire pump shall start automatically on further pressure drop or on jockey pump failure.

2.12. JOCKEY PUMP CONTROLLER

A. Furnish and install, where indicated on the drawings, a Joslyn Clark Type JS & JC jockey pump controller. Jockey pump controller shall be across the line, full voltage, and of the automatic type. The jockey pump controller shall be U.L. listed and in full compliance with all requirements of National Fire Protection Association, Pamphlet No. 20.

B. The jockey pump controller shall be furnished complete with service entrance rated, fusible disconnect, control transformer, and pressure switch.

C. The following standard Equipment and Performance features shall be provided with the jockey pump controller:

1. Automatic start responsive to water pressure, with integral pressure sensing switch.
2. Independent "high" and "low" adjustment points on pressure switch.
3. HOA (Hand-Off-Auto) selection switch.
4. Magnetic motor starter with thermal overload relay to provide 3-line overload protection.
5. Fusible disconnect, switch combination with power fuser.
6. External operator, equipped for pad locking in "OFF", which also locks the door closed.
7. External pressure switch connector.
8. NEMA 2 Enclosure.
9. Running period timer.
10. Full voltage starter.
11. Pilot Lamps/Lights

D. The jockey pump controller shall be capable of and designed for jockey pump scheduled horsepower, voltage, and phase. The exact size of the jockey pump controller shall be coordinated with the size of the jockey pump.

2.13. AUTOMATIC BALL DRIP VALVES

A. Provide and install automatic ball drip valves at both the Fire Department connection and the hose header test connection. Discharge ball drip valves to closest floor drain or building exterior as required with suitable air gap. Automatic ball drip valves shall be ITT-AC Pump, Reliable Automatic Sprinkler Co., Tyco Fire Products, or approved equal.

2.14. HOSE HEADER MANIFOLD VALVES

A. Provide and install approved hose header manifold with size and quantity of National Standard male hose threads as required by NFPA-20, with cap and chain. Unit shall be complete with 2 ½ inch valves in quantity as required by NFPA-20. Locate unit with center line at 3 feet above grade in the horizontal position. Connect to fire pump system through a normally closed, listed, OS&Y gate valve. Provide and install escutcheon at test header manifold lettered with "Fire Pump Test Header". Provide automatic ball drip and discharge to closest floor drain. Hose header manifold and valves shall be ITT A-C Pump or approved equal.

2.15. MAIN RELIEF VALVE

A. Provide and install a main relief, UL 1478 as indicated on contact drawings. Discharge main relief valve outside of pump house. Provide concrete splash block at main relief valve discharge. Main relief valves shall be sized, set, and installed per N.F.P.A.-20. Main relief valve shall be ITT A-C Pump, Watts, Cla-val or approved equal.

2.16. AUTOMATIC AIR RELEASE VALVE

A. Provide and install a ¾ inch automatic air release valve as shown on the contract drawings and in accordance with N.F.P.A.-20. Automatic Air Release valves shall be ITT A-C Pump or approved equal.

2.17. CIRCULATION RELIEF VALVE

A. Provide and install a ¾ inch circulation relief valve as shown on the contract drawings and in accordance with N.F.P.A.-20. Discharge circulation relief valve into closest floor drain with suitable air gap. Circulation relief valve shall be ITT A-C Pump or approved equal.

B. Where a flow meter test loop is installed, furnish and install an additional circulation relief valve.

2.18. VALVES

A. Provide and install control valves as indicated on contract drawings and as required by N.F.P.A.-13, and N.F.P.A.-14. Gate valves shall be listed O.S. & Y. type. All control valves shall be supervised open except test outlet control valve which shall be supervised closed. Supervision shall be as required by N.F.P.A.-13 and N.F.P.A.-14. Victaulic Series 705 and 765 grooved end butterfly valves shall be supervised in the open position and Victaulic Series 707 and 766 shall be supervised closed, for fire pump metering test lines for NFPA 20 as well as pressure reducing valve by-pass lines per NFPA-14.

B. Eccentric suction reducer and OS&Y gate valve on suction side of pump.

C. Concentric increaser and check valve in pump discharge and OS&Y gate valve on system side of check valve.

2.19. FIRE PUMP BYPASS

A. Where required by NFPA-20 and/or the authority having jurisdiction provide and install a fire pump bypass fitted with OS&Y gate or butterfly valves and check valves.

2.20. FLOW METERING SYSTEM

A. Where required by NFPA-20 and/or the authority having jurisdiction provide and install a flow metering system for closed loop testing in addition to test header piping.

B. Fire Pump Test Meters: Grooved end calibrated Venturi meter manufactured of carbon steel zinc electroplate body, brass needle valve conforming to ASTM B124 with attached GPM meter. Minimum straight pipe installation of five diameters upstream and two diameters downstream. Victaulic Series 735.

2.21. STANDPIPE HOSE VALVES

A. Standpipe angle valve shall be Potter Roemer 4020 series, Class I, 2½ inch angle valve, brass body, brass mounting, inside screw rising stem, red handle, cap and chain, pressure regulating up to 100 psig inlet pressure. Match threads to local fire department.

2.22. STANDPIPE VALVE CABINETS

A. Valve cabinets shall be fully recessed or surface mounted as indicated, Potter Roemer, 20 gauge steel cabinet, white polyester finish with continuous hinge, steel door with[lockable handle] glass. Standpipe valve cabinets shall be rated for installation in stairwell, fire rated wall. Valve cabinet locks shall match requirements of local Fire Department keys. Keys shall be located in exterior lock box. Coordinate with local Fire Department.

B. Pressure regulating fire department valve cabinet shall be the 1800 series as manufactured by Potter-Roemer, Larsens or approved equal.

2.23. BLIND FLANGE FOR FORWARD FLOW TESTING OF BACKFLOW PREVENTER

A. A blind flange with normally closed control valve shall be provided for use in forward flow testing of backflow preventer. Blind flange shall be sized to flow entire system demand in accordance with NFPA-13 and NFPA-25, latest edition. Control valve shall be monitored with tamper switch.

B. Identify and label blind flange Backflow Preventer Test Connection to differentiate fitting on exterior wall from Fire Department connection.

C. Install ball drip in test pipe to allow drainage and prevent freezing.

PART 3. EXECUTION

3.1. GENERAL INSTALLATION REQUIREMENTS

A. Install equipment in accordance with manufacturers' instructions.

B. Provide approved double detector check valve assembly at sprinkler system water source connection.

C. Locate fire department connection with sufficient clearance from walls, obstructions, or adjacent fire department connections to allow full swing of fire department wrench handle.

D. Locate outside alarm gong on building wall.

E. Place pipe runs to minimize obstruction to other work.

F. Place piping in concealed spaces above finished ceilings.

G. Center sprinklers in two directions in ceiling tile and provided piping offsets as required.

H. Apply masking tape or paper cover to ensure concealed sprinklers, cover plates, and sprinkler escutcheons do not receive field paint finish. Remove after painting. Replace painted sprinklers.

I. Flush entire piping system of foreign matter.

J. Install guards on sprinklers where specified.

K. Hydrostatically test entire system.

L. Require test be witnessed by Fire Marshal/authority having jurisdiction/ Owner's insurance underwriter and Architect/Engineer.

M. Refer to plumbing floor plans for approximate locations of sprinkler zones control valve assemblies and routing of fire protection mains.

N. Locate inspectors test stations for sprinkler zones per NFPA-13. Provide and install drain piping from all approved terminations. Provide splash blocks for terminations outside. Splash block locations shall be approved by the Architect.

O. The fire protection contractor shall hydraulically prove the most remote area per NFPA-13.

P. Coordinate locations of sprinkler heads with lights, diffusers, ceiling types, etc.

Q. Hydrostatically test system at 200 PSI for 4 hours, per NFPA-13.

R. Provide and install class III standpipe hose valves on each side of stage/platform per NFPA-13, NFPA-101, NFPA-14 and the International Building Code provide indicating control valve for each hose valve.

S. Provide dry pipe sprinklers at all loading docks, canopies, walk-in freezers, etc., as required by NFPA-13.

T. Refer to Architectural Drawings for exact location and extent of all fire rated walls and smoke barriers.

U. Sprinkler shall be provided at top and bottom of the elevator shaft as per NFPA-13, latest edition.

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

W. A separate control valve with tamper switch shall be installed for the top and bottom of the elevator shaft and elevator machine room.

X. Grooved joint piping systems shall be installed in accordance with the manufacturer’s (Victaulic) guidelines and recommendations. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be molded and produced by Victaulic. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealings.

3.2. INTERFACE WITH OTHER PRODUCTS

A. Ensure required devices are installed and connected as required to fire alarm system.

3.3. FIRE PUMP INSTALLATION REQUIREMENTS

A. Install in accordance with NFPA-20.

B. Provide access space around pumps for service, no less than minimum as recommended by manufacturer.

C. Install piping in accordance with Division 21 Section, Fire Suppression System Piping, Fittings, Valves, etc. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For base mounted pumps, provide supports under elbows on pump suction and discharge.

D. Provide drains from bases and seals, piped to and discharging in floor drains.

E. Mount fire pump on vibration isolators and 4 inch high concrete housekeeping pad. Grout pump base with non-shrink grout.

F. Provide for connection to electrical service. Refer to Division 26.

G. Lubricate pumps before start-up.

H. Check, align, and certify fire pumps and pressure maintenance pumps by qualified millwright prior to start-up.

I. Perform flow test on entire system in accordance with NFPA-20.

J. Require test to be witnessed by Fire Marshal, authority having jurisdiction, Owner's insurance underwriter, Architect/Engineer.

K. Demonstrate automatic operation of system including verification of pressure switch set points.

L. Install pumps and controllers to provide access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

M. Set pumps on concrete bases. Disconnect coupling halves before setting. Do not reconnect couplings until alignment operations have been completed.

1. Support pump baseplate on rectangular metal blocks and shims or on metal wedges having small taper, at points near anchor bolts, to provide 3/4- to 1-1/2-inch (19- to 38-mm) gap between pump base and concrete base for grouting.
2. Adjust metal supports or wedges until pump and driver shafts are level. Verify that coupling faces and pump suction and discharge flanges are level and plumb.

N. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections and to assist in field testing. Report results in writing.

O. Perform field tests for each fire pump when installation is complete. Comply with operating instructions and procedures in NFPA 20 to demonstrate compliance with requirements. Where possible, field correct malfunctioning equipment, then retest to demonstrate compliance. Replace equipment that cannot be satisfactorily corrected or that does not perform as indicated, then retest to demonstrate compliance. Verify that each fire pump performs as indicated. Verify operation of fire pump when emergency power is "on".

P. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Final Checks before Startup: Perform the following preventive-maintenance operations and checks:

   a. Lubricate oil-lubrication-type bearings.
   b. Remove grease-lubrication-type bearing covers, flush bearings with kerosene, and clean thoroughly. Fill with new lubricant according to manufacturer's written instructions.
   c. Disconnect coupling and check electric motor for proper rotation. Rotation shall match direction of rotation marked on pump casing.
   d. Verify that pump is free to rotate by hand. If pump is bound or if it drags even slightly, do not operate until cause of trouble is determined and corrected.

3. Starting procedure for pumps is as follows:

   a. Prime pump by opening suction valve and closing drains, and prepare pump for operation.

b. Open sealing-liquid supply valves if pump is so fitted.
c. Start motor.
d. Open discharge valve slowly.
e. Observe leakage from stuffing boxes and adjust sealing-liquid valve for proper flow to ensure lubrication of packing. Do not tighten gland immediately, but let packing run in before reducing leakage through stuffing boxes.
f. Check general mechanical operation of pump and motor.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Fire hoses are for field-acceptance tests only and are not property of Owner.

Q. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire pumps, drivers, controllers, and pressure-maintenance pumps. Refer to Division 01 Section, Closeout Procedures and Demonstration and Training.

3.4. STANDPIPE AND HOSE VALVE INSTALLATION REQUIREMENTS

A. Install in accordance with manufacturer’s instructions.

B. Install in accordance with NFPA-14.

C. Locate and secure cabinets plumb and level. Establish top of cabinet surface 66 inches above finished floor.

D. Locate hose station valve in cabinet at 60 inches above floor. Locate hose connection valve below hose station valve and not closer than 4 inches from side or bottom of cabinet.

E. Where static pressure exceeds 100 psi but is less than 100 psi at any hose station, provide pressure orifice disc in discharge of hose station valve to prevent pressure on hose exceeding 90 psi.

F. Where static pressure exceeds 100 psi at any hose station, provide pressure reducing valve to prevent pressure on hose exceeding 90 psi.

G. Where required by Code or Fire Marshal, provide two way fire department outlet connection on roof.

H. Flush entire system of foreign matter.

I. Install control valves on each standpipe riser and pressure gauges at the top of each standpipe.

3.5. LAYOUT

A. Coordinate layout and installation of fire protection system with all other buildings structural, mechanical and electrical work. Locate sprinkler heads symmetrically with respect to ceiling tiles, lighting fixtures, registers, grilles, diffusers, etc. Provide piping offsets as required to maintain symmetry. Note that a preliminary sprinkler layout is to be submitted for review. Contractor is cautioned that sprinkler mains must be located to prevent conflict with other work and in any case, sprinkler contractor shall be responsible for coordination of his work with work of other trades.

B. Unless otherwise indicated, the entire building including pump room shall be protected throughout with a wet pipe sprinkler system. Where required by NFPA-13 and/or the authority having jurisdiction, install sprinkler heads above and below ceilings.

3.6. WET PIPE SPRINKLER SYSTEM

A. System components shall, but not be limited to include flow control valves, electrical connection to central fire alarm system, fire department connection, check valves, main piping, branch piping, inspector's test, drains, sprinkler heads, hose valves and cabinet, ball drip valves, signs, fire pump, jockey pumps, controllers, standpipes, etc. and all other incidental appurtenances as required.

B. Entire fire pump room shall be fully sprinklered.

3.7. VALVE INSTALLATION

A. Gate Valves: Install fire-protection-service valves supervised-open, located to control sources of water supply except from fire department connections. Provide permanent identification signs indicating portion of system controlled by each valve.

B. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water supply sources.

C. Alarm Check Valves: Install valves in vertical position for proper direction of flow, including bypass check valve and retard chamber drain-line connection.

D. Do not install any control valves other than an OS&Y gate valve within 50 feet of the fire pump suction.

E. Install supervised control valve on test header piping and interlock with fire alarm system.

3.8. CONNECTIONS

A. Connect water supplies to standpipes and sprinklers. Include backflow preventers.

B. Install ball drip valves at each check valve for fire department connection. Drain to floor drain or outside building.

C. Connect piping to specialty valves, specialties, fire department connections, and accessories.

D. Connect alarm devices to fire alarm.

E. Test automatic transfer switch, all remote alarms, and interface with emergency generator.

3.9. COMMISSIONING

A. Verify that specialty valves, trim, fittings, controls, and accessories are installed and operate correctly.

B. Verify that specified tests of piping are complete.

C. Verify that damaged sprinklers and sprinklers with paint or coating not specified are replaced with new, correct type.

D. Verify that sprinklers are correct types, have correct finishes and temperature ratings, and have guards as required for each application.

E. Verify that potable-water supplies have correct types of backflow preventers.

F. Verify that fire department connections have threads compatible with local fire department equipment

G. Fill wet-pipe sprinkler piping with water.

H. Energize circuits to electrical equipment and devices.

I. Adjust operating controls and pressure settings.

J. Coordinate with fire alarm tests. Operate as required.

3.10. DRAINS

A. The sprinkler system shall be arranged to be completely drainable. Means of drainage shall be provided with adequate protection from freezing.

3.11. TESTS

A. The sprinkler systems installation shall be hydrostatically tested, inspected, and approved, in accordance with NFPA Standard No. 13, NFPA Standard No. 14, NFPA Standard No. 20 and N.F.P.A. Standard No. 25. Test certificate shall be forwarded to the Office of the State Fire Marshal and the Architect as proof of compliance.

B. Tests shall be performed in accordance with the requirements of the Office of the State Fire Marshal and shall prove the systems to be adequate and satisfactory in every respect. All tests shall be performed in the presence of the State Fire Marshal or his representative.

C. Any deficiencies revealed by these tests shall be corrected and the systems shall be retested until acceptable results are obtained.

D. Fire Protection Contractor shall provide all equipment and water necessary for testing the fire pump, and associated equipment.

3.12. AS-BUILT DRAWINGS & PROJECT CLOSEOUT

A. Provide separate as-built drawings of all fire protection systems meeting requirements of

Division 21 Section, Common Work Results for Fire Protection Systems herein before specified.

B. At the completion of the work, provide a sealed plan of the building indicating the locations of all control valves, low point drains, flow switches, and Inspectors Test Stations. The plan shall be neatly drawn and color coded to indicate the portion of the building protected by each system, framed under glass and permanently mounted on the wall adjacent to the system header.

C. Include manufacturers' literature, cleaning procedures, replacement parts, lists, and repair data for pumps, drivers, controllers, and equipment.

D. Include manufacturers' instructions, start-up data, troubleshooting, checklists for pumps, drivers, controllers and equipment.

E. Include a list of recommended spare parts and lubricants.

3.13. WARRANTY

A. The Contractor's attention is directed to the warranty obligations contained in the Article of the General Conditions of the specifications entitled "Warranty".

3.14. OWNER TRAINING

A. Upon completion of the project, furnish a complete copy of NFPA-25 and NFPA-20 to Owner. Provide correspondence indicating that the pamphlets have been turned over to the Owner.

1. Contractor shall provide at least eight (8) hours of training to the Owner on the proper inspection, testing, and maintenance of the installed fire protection system.
2. Schedule training with the Owner through the Architect and/or Engineer with at least seven (7) days prior notice.
3. A Victaulic factory-trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

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DIVISION 22 SECTION 22 05 00
COMMON WORK RESULTS FOR PLUMBING
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SECTION 22 05 00 - COMMON WORK RESULTS FOR PLUMBING

PART 1. GENERAL

1.1. SUMMARY

A. All work under Division 22 is subject to the Division 01, General Requirements, the General Conditions and Supplementary Conditions.

B. Provide all labor, materials, equipment, and services necessary for and incidental to the complete installation and operation of all plumbing work.

C. Unless otherwise specified, all submissions shall be made to, and acceptances and approvals made by the Architect and the Engineer.

D. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions and accessories are not necessarily shown. Furnish and install all such items as may be required to fit the work to the conditions encountered. Arrange piping, equipment, and other work generally as shown on the contract drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawings for approval in accordance with Submittals specified below. The right is reserved to make reasonable changes in location of equipment, piping, up to the time of rough-in or fabrication.

E. Conform to the requirements of all rules, regulations and codes of local, state and federal authorities having jurisdiction.

F. Coordinate the work under Division 22 with the work of all other construction trades.

G. Be responsible for all construction means, methods, techniques, procedures, and phasing sequences used in the work. Furnish all tools, equipment and materials necessary to properly perform the work in first class, substantial, and workmanlike manner, in accordance with the full intent and meaning of the contract documents.

1.2. PERMITS AND FEES

A. Obtain all permits and pay taxes, fees and other costs in connection with the work. File necessary plans, prepare documents, give proper notices and obtain necessary approvals. Deliver inspection and approval certificates to Owner prior to final acceptance of the work.

B. Permits and fees shall comply with the Division 01, General Requirements of the specification.

1.3. EXAMINATION OF SITE

A. Examine the site, determine all conditions and circumstances under which the work must be done, and make all necessary allowances for same. No additional cost to the Owner will be permitted for contractors failure to do so.

B. Examine and verify specific conditions described in individual specifications sections.

C. Verify that utility services are available, of the correct characteristics, and in the correct locations.

1.4. CONTRACTOR QUALIFICATION

A. Any Contractor or Subcontractor performing work under Division 22 shall be fully qualified and acceptable to the Architect and Owner. Submit the following evidence when requested:

1. A list of not less than five comparable projects which the Contractor completed.
2. Letter of reference from not less than three registered professional engineers, general contractors or building owners.
3. Local and/or State License, where required.
4. Membership in trade or professional organizations where required.

B. A Contractor is any individual, partnership, or corporation, performing work by contract or subcontract on this project.

C. Acceptance of a Contractor or Subcontractor will not relieve the Contractor or subcontractor of any contractual requirements or his responsibility to supervise and coordinate the work, of various trades.

1.5. MATERIALS AND EQUIPMENT

A. Materials and equipment installed as a permanent part of the project shall be new, unless otherwise indicated or specified, and of the specified type and quality.

B. Where material or equipment is identified by proprietary name, model number and/or manufacturer, furnish named item, or its equal, subject to approval by Engineer. Substituted items shall be equal or better in quality and performance and must be suitable for available space, required arrangement, and application. Submit all data necessary to determine suitability of substituted items, for approval.

C. The suitability of named item only has been verified. Where more than one item is named, only the first named item has been verified as suitable. Substituted items, including items other than first named shall be equal or better in quality and performance to that of specified items, and must be suitable for available space, required arrangement and application. Contractor, by providing other than the first named manufacturer, assumes responsibility for all necessary adjustments and modifications necessary for a satisfactory installation. Adjustments and modifications shall include but not be limited to electrical, structural, support, and architectural work.

D. Substitution will not be permitted for specified items of material or equipment where noted.

E. All items of equipment furnished shall have a service record of at least five (5) years.

1.6. FIRE SAFE MATERIALS

A. Unless otherwise indicated, materials and equipment shall conform to UL, NFPA and ASTM standards for fire safety with smoke and fire hazard rating not exceeding flame spread of 25 and smoke developed of 50.

1.7. REFERENCED STANDARDS, CODES AND SPECIFICATIONS

A. Specifications, Codes and Standards listed below are included as part of this specification, latest edition.

B. ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers

C. ASME - American Society of Mechanical Engineers

D. ASPE - American Society of Plumbing Engineers

E. ASTM - American Society for Testing and Materials

F. AWWA - American Water Works Association

G. CS - Commercial Standard

H. CSD Control and Safety Devices

I. DNREC - Delaware Department of Natural Resources and Environmental Control

J. FM - Factory Mutual

K. IBC - International Building Code

L. IEEE - Institute of Electrical and Electronics Engineers

M. MSSP - Manufacturers Standards Society of the Valve and Fittings Industry

N. NEC - National Electrical Code

O. NEMA - National Electrical Manufacturers Association

P. NSF - National Sanitation Foundation

Q. UL - Underwriters' Laboratories

R. All plumbing equipment and materials shall comply with the codes and standards listed in the latest edition of ASHRAE HVAC Applications Handbook, Chapter entitled Codes and Standards.

1.8. SUBMITTALS, REVIEW AND ACCEPTANCE

A. Equipment, materials, installation, workmanship and arrangement of work are subject to review and acceptance. No substitution will be permitted after acceptance of equipment or materials except where such substitution is considered by the Architect to be in best interest of Owner.

B. After acceptance of Material and Equipment List, submit six (6) copies or more as required under General Conditions of complete descriptive data for all items. Data shall consist of specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, wiring diagrams, installation instructions, and any other information necessary to indicate complete compliance with Contract Documents. Edit submittal data specifically for application to this project.

C. Thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission. Coordinate installation requirements and any electrical requirements for equipment submitted. Contractor shall be responsible for correctness of all submittals.

D. Submittals will be reviewed for general compliance with design concept in accordance with contract documents, but dimensions, quantities, or other details will not be verified.

E. Identify submittals, indicating intended application, location and service of submitted items. Refer to specification sections or paragraphs and drawings where applicable. Clearly indicate exact type, model number, style, size and special features of proposed item. Submittals of a general nature will not be acceptable. For substituted items, clearly list on the first page of the submittal all differences between the specified item and the proposed item. The contractor shall be responsible for corrective action and maintaining the specification requirements if differences have not been clearly indicated in the submittal.

F. Submit actual operating conditions or characteristics for all equipment where required capacities are indicated. Factory order forms showing only required capacities will not be acceptable. Call attention, in writing, to deviation from contract requirements.

G. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted. Use only final or corrected submittals and data prior to fabrication and/or installation.

H. For any submittal requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.

I. For resubmissions, the Contractor must address in writing all of the Engineer’s comments on the original submission to verify compliance.

1.9. SHOP DRAWINGS

A. Prepare and submit shop drawings for all plumbing equipment, specially fabricated items, modifications to standard items, specially designed systems where detailed design is not shown on the contract drawings, or where the proposed installation differs from that shown on contract drawings.

B. Submit data and shop drawings including but not limited to the list below, in addition to provisions of the paragraph above. Identify all shop drawings by the name of the item and system and the applicable specification paragraph number and drawing number.

C. Every submittal including, but not limited to the list below, shall be forwarded with its own transmittal as a separate, distinct shop drawing. Grouping of items/systems that are not related shall be unacceptable.

D. Items and Systems

1. Access Doors/Panels including layout and location
2. Automatic Temperature Control System and Equipment as it relates to plumbing system
3. Art Room Sink Plaster Traps
4. Backflow Preventers
5. Backwater Valves
6. Coordinated Drawings
7. Condensate Neutralizers
8. Direct Buried Piping
9. Domestic Booster Pumps
10. Domestic Water Expansion Tanks
11. Domestic Water Heaters
12. Drain Valves
13. Drip Pans
14. Elevator Sump Pumps
15. Equipment Rails
16. Exterior Equipment/Piping Supports
17. Exterior Pipe Roller Support
18. Fire Stopping - Methods and Materials
19. Floor and Roof Drains
20. Gas Fired Domestic Water Heaters
21. Gas Pressure Regulating Valves
22. Gas Quick Disconnect Valves
23. Kitchen Gas Solenoid Valves
24. High/low Mixing Valves
25. Hose Bibbs and Wall Hydrants
26. Identification System
27. In-Line Circulators
28. Interceptors
29. Makeup Water Meters
30. Material and Equipment List
31. Operations and Maintenance Manuals
32. Pipe Enclosures
33. Pipe Guides and Anchors.
34. Pipe Materials Including Itemized Schedule
35. Plumbing Fixtures & Trim
36. Preliminary Testing and Balancing Report
37. Pre-Pressurized Hydro-Pneumatic Tanks
38. Pressure/Temperature Relief Valves
39. Pressure Regulating Valves
40. Pumps
41. Roof Curbs
42. Roof Drains
43. Roof Hydrants
44. Screenshots of ATC System Graphics

45. Shock Absorbers
46. Strainers
47. Test Certificates
48. Thermal Insulation Materials Include Table Summary
49. Thermometers and Gauges
50. Thermostatic Mixing Valves
51. Trap Priming Station/Valves
52. Vacuum Breakers
53. Valves
54. Variable Frequency Drive Motor Bearing Protective Rings
55. Variable Speed Drives
56. Vibration Isolation Materials
57. Water Meters
58. Weatherproof Assembly Components
59. Wiring Diagrams, Flow Diagrams and Operating Instructions

E. Contractor, additionally, shall submit for review any other shop drawings as required by the Architect. No item shall be delivered to the site, or installed, until the Contractor has received a submittal from the Engineer marked Reviewed or Comments Noted. After the proposed materials have been reviewed, no substitution will be permitted except where approved by the Architect.

1.10. SUPERVISION AND COORDINATION

A. Provide complete supervision, direction, scheduling, and coordination of all work under the Contract, including that of subcontractors.

B. Coordinate rough-in of all work and installation of sleeves, anchors, and supports for piping, equipment, and other work performed under Division 22.

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

D. Coordinate electrical work required under Division 22 with that under Division 26. Coordinate all work under Division 22 with work under all other Divisions.

E. Supply services of an experienced (10 years minimum) and competent Project Manager to be in constant charge of work at site.

F. Where a discrepancy exists within the specifications or drawings or between the specifications and drawings, the more stringent (or costly) requirement shall apply until clarification can be obtained from the Engineer. Failure to clarify such discrepancies with the Engineer will not relieve the Contractor of the responsibility of conforming to the requirements of the Contract.

G. Failure of contractor to obtain a full and complete set of contract documents (either before or after bidding) will not relieve the contractor of the responsibility of complying with the intent of the contract documents.

H. Coordinate installation of large equipment requiring positioning before closing in building.

1.11. CUTTING AND PATCHING

A. Accomplish all cutting and patching necessary for the installation of work under Division 22. Damage resulting from this work to other work already in place, shall be repaired at Contractor's expense. Where cutting is required, perform work in neat and work¬manlike manner. Restore disturbed work to match and blend with existing construction and finish, using materials compatible with the original. Use mechanics skilled in the particular trades required.

B. Do not cut structural members without approval from the Architect or Engineer.

1.12. PENETRATION OF WATERPROOF CONSTRUCTION

A. Coordinate the work to minimize penetration of waterproof construction, including roofs, exterior walls, and interior waterproof construction. Where such penetrations are necessary, furnish and install all necessary curbs, sleeves, flashings, fittings and caulking to make penetrations absolutely watertight.

B. Where plumbing vents or other pipes penetrate roofs, flash pipe with Stoneman Stormtite, Pate or approved equal, roof flashing assemblies with skirt and caulked counter flashing sleeve.

C. Furnish and install pitch pockets or weather tight curb assemblies where required.

D. Furnish and install roof drains, curbs, and vent assemblies specifically designed for application to the particular roof construction, and install in accordance with the manufacturer's instructions. The Contractor shall be responsible for sleeve sizes and locations. All roof penetrations shall be installed in accordance with manufacturer’s instructions, the National Roofing Contractors Association, SMACNA, and as required by other divisions of these specifications.

1.13. CONCRETE AND MASONRY WORK

A. Furnish and install concrete and masonry work for equipment founda¬tions, supports, pads, and other items required under Division 22. Perform work in accordance with requirements of other applicable Divisions of these specifications.

B. Concrete shall test not less than 3,000 psi compressive strength after 28 days.

C. Grout shall be non-shrink, high strength mortar, free of iron of chlorides and suitable for use in contact with all metals, without caps or other protective finishes. Apply in accordance with manufacturer's instructions and standard grouting practices.

1.14. CONNECTIONS AND ALTERATIONS TO EXISTING WORK

A. Unless otherwise noted on the drawings, where existing plumbing work is removed all pipes, valves, etc., shall be removed, including hangers, to a point below finished floors or behind finished walls and capped. Such point shall be far enough behind finished surfaces to allow for installation of normal thickness of required finish material.

B. Where work specified in Division 22 connects to existing equipment, piping, etc., Contractor shall perform all necessary alterations, cuttings, fittings, etc., of existing work as may be necessary to make satisfactory connections between new and existing work, and to leave completed work in a finished and workmanlike condition.

C. Where the work specified under Division 22, or under other Divisions, requires relocation of existing equipment, piping, etc., Contractor shall perform all work and make necessary changes to existing work as may be required to leave completed work in a finished and workmanlike condition. Where existing insulation is disturbed, replace insulation where removed or damaged equal to existing, in type, thickness, density, finish and thermal resistance (R-value) value.

D. Where the relocation of existing equipment is required for access or the installation of new equipment, the contractor shall temporarily remove and/or relocate and re-install as required to leave the existing and new work in a finished and workman like condition.

1.15. EXCAVATION AND BACKFILLING

A. GENERAL

1. Perform all necessary excavation, or installation of work under Division 22, in whatever materials or conditions encountered, using suitable methods and equipment.
2. Accurately establish required lines and grades and properly locate the work.
3. Determine the locations of all existing utilities before commencing the work.

B. Excavation: (Refer also to other portions of the specifications)

1. Excavate only the required elevations. If excavation is carried below the foundation lines or other required limits, backfill the excess with concrete.
2. Keep banks of trenches as nearly vertical as possible, and provide sheeting and/or shoring as required for protection of work and safety of personnel. Follow local, State, OSHA Guidelines.
3. Keep excavations dry. Protect excavations from freezing.

C. Backfilling: (Refer also to other portions of the specifications)

1. Backfill excavations to the required elevations and restore surfaces to their original or required conditions.
2. Backfill shall be similar material, free from objectionable matter such as rubbish, roots, stumps, brush, rocks and other sharp objects. Unless otherwise indicated, suitable material from the excavation may be used for backfill.
3. Carefully place and mechanically tamp backfill in layers not exceeding 12 inches loose thickness. Compact to 95 percent minimum.
4. Do not backfill against frozen material. Do not use frozen material for backfill.

1.16. DRIVE GUARDS

A. Provide safety guards on all exposed belt drives, motor couplings, and other rotating machinery. Provide fully enclosed guards where machinery is exposed from more than one direction.

B. When available, guards shall be factory fabricated and furnished with the equipment. Otherwise fabricate guards of heavy gauge steel, rigidly braced, removable, and finish to match equipment served. Provide openings for tachometers. Guards shall meet local, State and O.S.H.A. requirements.

1.17. VIBRATION ISOLATION

A. Furnish and install vibration isolators, flexible connections, supports, anchors and/or foundations required to prevent transmission of vibration from equipment, or piping to building structure. See Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection.

1.18. ALTERNATES

A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

1.19. DEFINITIONS

A. Approve - to permit use of material, equipment or methods conditional upon compliance with contract documents requirements.

B. Furnish and install or provide means to supply, erect, install, and connect to complete for readiness for regular operation, the particular work referred to.

C. Contractor means the mechanical contractor and any of his subcontractors, vendors, suppliers, or fabricators.

D. Piping includes pipe, all fittings, valves, hangers, insulation, identification, and other accessories relative to such piping.

E. Concealed means hidden from sight in chases, formed spaces, shafts, hung ceilings, embedded in construction or in crawl space.

F. Exposed means not installed underground or concealed as defined above.

G. Invert Elevation means the elevation of the inside bottom of pipe.

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

I. Review - limited observation or checking to ascertain general conformance with design concept of the work and with information given in contract documents. Such action does not constitute a waiver or alteration of the contract requirements.

J. Building Line: Exterior wall of building.

1.20. MINIMUM EFFICIENCY REQUIREMENTS

A. All plumbing equipment shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.

B. All piping and equipment insulation shall comply with ASHRAE Standard 90.1, latest edition.

C. All service water/heating equipment shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.

D. All plumbing devices, controls, accessories, and components shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.

E. Department of Energy (DOE) compliance: Pump manufacturers shall comply with US Department of Energy (DOE) energy conservation standard for “clean water pumps” 1-200 horse power, less than 459 feet of head and greater than 25 gpm. These pumps shall be evaluated using the Pump Energy Index (PEI) of equal to or lesser than 1.0. The PEI number shall appear on the pump name plate and available for the record at http://er.pumps.org.

F. Where Energy Star certification exists for equipment utilized on this project, the equipment must be Energy Star certified. Provide Energy Star certification with submittals.

1.21. FUTURE ADDITIONS

A. Where future additions are indicated, install all piping to account for future additions. Furnish and install shut-off valve in ceiling adjacent to future additions. Provide cap at the end of the piping. Arrange so that in the future the cap can be removed and shut-off valve opened to serve future addition without draining system. Install bypass with balance valve and shut-off valve on domestic recirc system. Balance to future flow rate and then shut the bypass balance valve.

1.22. SYSTEM INTEGRATION

A. For all plumbing equipment specified to be provided with packaged controls and interfaced with the automatic temperature control system, provide system integration between the equipment manufacturer and the automatic temperature control subcontractor.

B. Plumbing equipment submittals requiring system integration as defined above must identify all required system integration points.

C. Plumbing equipment manufacturers must coordinate with ATC subcontractor regarding system integration prior to submitting on the equipment.

D. A system integration meeting must be arranged by the Mechanical Contractor and include, but not be limited to the systems integrator for the plumbing equipment manufacturer and the ATC Subcontractor. This portion of systems integration must occur prior to plumbing equipment being delivered to the project.

E. Once the plumbing equipment is on site, a second systems integration meeting must be arranged by the Mechanical Contractor to coordinate the packaged controls with the ATC system. The plumbing equipment manufacturer’s representative familiar with system integration and the ATC subcontractor familiar with programming must be present.

F. A final system integrations meeting shall occur once all equipment is in place and ready for operation. The Mechanical Contractor, the plumbing equipment systems' integrator, and the ATC Subcontractor shall meet on site to jointly program, schedule, verify points, interlock devices, and fully set up all systems integration components.

G. All systems integration coordination, programming, and graphics must be completed prior to requesting commissioning and/or inspections by the Engineer of Record.

1.23. LEAD FREE REQUIREMENTS

A. All plumbing fixtures, equipment, and devices that contact potable water must be lead free per the State requirements. Potable water systems shall also comply with NSF 61 – Annex G and NSF-372.

1.24. COORDINATION WITH SMYRNA SCHOOL DISTRICT I.T. DEPARTMENT

A. All equipment that interfaces with the internet shall be coordinated with the Smyrna School District I.T. Department to verify that the same is suitable for use on the Smyrna School District IT infrastructure. Coordinate with the Smyrna School District I.T. Department regarding the allowable frequency bands to avoid interference with the Smyrna School District I.T. infrastructure.

1.25. EXTRA MATERIALS

A. Provide one set of seals for each type and model of pump provided on the project.

PART 2. ELECTRICAL REQUIREMENTS

2.1. GENERAL MOTOR AND ELECTRICAL REQUIREMENTS

A. Furnish and install control and interlock wiring for the equipment furnished. In general, power wiring and motor starting equipment will be provided under Division 26. Carefully review the contract documents to coordinate the electrical work under Division 22 with the work under Division 26. Where the electrical requirements of the equipment furnished differ from the provisions made under Division 26, make the necessary allowances under Division 22. Where no electrical provisions are made under Division 26, include all necessary electrical work under Division 22.

B. All electrical work performed under Division 22 shall conform to the applicable requirements of Division 26 and conforming to the National Electrical Code. All wiring, conduit, etc., installed in ceiling plenums must be plenum rated per NFPA & International Building Code.

C. Provide wiring diagrams with electrical characteristics and connection requirements.

D. Test Reports: Indicate test results verifying nominal efficiency and power factor for three phase motors larger than five (5) horsepower.

E. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof covering. For extended outdoor storage, remove motors from equipment and store separately.

F. All motors shall be furnished with visible nameplate indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor and efficiency.

G. Motors located in exterior locations, wet air streams and outdoors shall be totally enclosed weatherproof epoxy-treated type.

H. Nominal efficiency and power factor shall be as scheduled at full load and rated voltage when tested in accordance with IEEE 112.

I. Brake horsepower load requirement at specified duty shall not exceed 85 percent of nameplate horsepower times NEMA service factor for motors with 1.0 and 1.15 service factors.

J. All single phase motors shall be provided with thermal protection: Internal protection shall automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature ratings of motor insulation. Thermal protection device shall automatically reset when motor temperature returns to normal range, unless otherwise indicated.

K. Where a motor disconnect is indicated downstream of a variable frequency drive (VFD) provide interlock wiring from the auxiliary contacts on the disconnect to the VFD to de-energize when the disconnect is turned "off".

L. Where equipment under this Division is specified with integral disconnecting means, the same shall be a single disconnecting means for disconnecting all ungrounded main power supply conductors that is capable of being locked in the open ("off") position in accordance with the National Electrical Code and the local electrical inspector.

2.2. MOTORS AND CONTROLS

A. Motors and controls shall conform to the latest requirements of IEEE, NEMA, NFPA-70 and shall be UL listed. Motor sizes are specified with the driven equipment. Motor starting and control equipment is specified either with the motor which is controlled or in an electrical specification section. The Contractor is advised to consult all specification sections to determine responsibility for motors and controls.

B. Motors shall be designed, built and tested in accordance with the latest revision of NEMA Standard MG l.

C. Motors used with variable-frequency controllers shall have ratings, characteristics, and features coordinated with and approved by the variable frequency controller (drive) manufacturer. As a minimum the following shall apply to variable frequency controlled motors:

1. Motors shall be manufactured to withstand peak voltages of 1600 volts with .1 microsecond rise time per NEMA MG-1.
2. Critical vibration frequencies of motor shall not be within operating range of

variable frequency controller output.

3. Temperature rise: Match rating for Class B insulation.
4. Insulation: Class F.
5. Thermal Protection: Conform to MG1 requirements for thermally protected motors.

D. Motors shall be suitable for use under the conditions and with the equipment to which applied, and designed for operation on the electrical systems specified or indicated.

1. Motor capacities shall be such that the horsepower rating and the rated full-load current will not be exceeded while operating under the specified operating conditions. Under no condition shall the motor current exceed that indicated on the nameplates.
2. Motor sizes noted in the individual equipment specifications are minimum requirements only. It is the responsibility of the equipment manufacturers and of the Contractor to furnish motors, electrical circuits and equipment of ample capacity to operate the equipment without overloading, exceeding the rated full-load current, or overheating at full-load capacity under the most severe operating service of this equipment. Motors shall have sufficient torque to accelerate the total WR2 of the driven equipment to operating speed.
3. Motors shall be continuous duty type and shall operate quietly at all speeds and loads.
4. Motors shall be designed for operation on 60 hertz power service. Unless otherwise specified or shown, motors less than ½ horsepower shall be single phase, and motors ½ horsepower and larger shall be 3 phase unless otherwise noted.
5. Motors shall be mounted so that the motor can be removed without removing the entire driven unit.

E. Single phase motors, smaller than 1/20 horsepower shall be ball or sleeve bearing; drip-proof, totally enclosed or explosion proof, as specified; 120 volts; permanent-split capacitor or shaded pole type. These motors shall not be used for general power purposes, and shall only be provided as built-in components of plumbing equipment. When approved by the Engineer, deviations from the specifications will be permitted as follows:

1. Open motors may be installed as part of an assembly where enclosure within a cabinet provides protection against moisture.
2. Motors used in conjunction with low voltage control systems may have a voltage rating less than 115 volts.

F. Single phase motors, greater than 1/20 horsepower and less than ½ horsepower shall be ball bearing; drip-proof, totally enclosed or explosion proof, as specified, with Class A or B insulation, as standard with the motor manufacturer; 115 or 120/208/240 volts as required; capacitor start-induction run, permanent split capacitor, or repulsion start-induction run type with minimum efficiency of 70 percent and a minimum full load power of 77 percent.

G. Except as otherwise specified in the various specification sections, 3 phase motors 60 horsepower and smaller shall be NEMA design B squirrel cage induction type meeting the requirements of this paragraph. Motors shall be drip-proof, totally enclosed or explosion proof, as specified or indicated. Insulation shall be Class B or F, at 40 degrees C ambient temperature. Drip-proof motors shall have a 1.15 service factor and totally enclosed and explosion proof motors shall have a service factor of 1.00 or higher. Motors specified for operation at 480, 240, and 208 volts shall be nameplated 460, 230, 200 volts, respectively. Efficiencies and percent power factor at full load for three phase motors shall be not less than the values listed below for premium efficiency motors:

MOTOR NAMEPLATE	MINIMUM PERCENT EFFICIENCY AT NOMINAL SPEED AND RATED LOAD	MINIMUM PERCENT POWER FACTOR
1HP and above to	85.5 percent	84 percent
1-½ HP	86.5 percent	85 percent
2HP	86.5 percent	85 percent
3HP	89.5 percent	86 percent
5HP	89.5 percent	87 percent
7½ HP	91 percent	86 percent
10HP	91.7 percent	85 percent
15HP	93.0 percent	85 percent

H. Three phase motors ½ HP or greater shall be the Duty Master XE by Reliance Electric Company, Super-E Premium Efficiency of Baldor Motor and Drives, E-plus Efficient Standard Duty Motor of the Electric Motor Division of Gould, Inc., the MAC II High Efficiency motor of Westinghouse Electric Corp., the equivalent product of General Electric, or approved equal.

I. For motors serving equipment being controlled by a variable speed drive, motor shall be premium efficiency inverter duty rated.

J. Motor frames shall be NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast-iron or aluminum with steel inserts.

K. Control of each motor shall be manual or automatic as specified for each in the various mechanical sections. In general, and unless otherwise specified for a particular item in the various mechanical sections of the specifications, motor starters and controls shall be specified and provided under the various electrical sections of these specifications.

2.3. MOTOR INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Install securely on firm foundation. Mount ball bearing motors to support shaft regardless of shaft position.

C. Check line voltage and phase and ensure agreement with nameplate. Check that proper thermal overloads have been installed prior to operating motors.

2.4. WIRING DIAGRAMS

A. The Contractor is responsible for obtaining and submitting wiring diagrams for all major items of equipment.

B. Wiring diagrams shall be provided with shop drawings for all equipment requiring electric power.

C. Provide wiring diagrams for all major plumbing items of equipment to electrical contractor and ATC subcontractor for coordination.

2.5. VARIABLE FREQUENCY DRIVE MOTOR BEARING PROTECTIVE RINGS:

A. For all motors driven by a variable frequency PWM drive include a maintenance free, circumferential, conductive micro fiber shaft grounding ring to discharge shaft currents. Grounding rings shall be manufactured by AEGIS SGR or approved equal.

B. Furnish units with one year warranty.

C. Size and select Bearing Protective Rings per the manufacturer requirements based on the motor size, shaft diameter, and shaft shoulder length. For motors with slingers furnish and install NEMA /IEC kit as required.

D. Furnish and apply Colloidal silver shaft coating to all shafts with Bearing Protective Rings to improve shaft voltage discharge capability.

2.6. ENCLOSURES

A. Electrical enclosures including factory provided enclosures, field provided and installed enclosures, and automatic temperature control system enclosures shall be as follows:

1. Dry Interior Locations: NEMA 1.
2. Damp/Wet Locations, Including Exterior Locations: NEMA 3R.
3. Corrosive Locations, Including Chemical Storage Rooms and Similar Space = NEMA 4X.

PART 3. EXECUTION

3.1. EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to provide maximum possible headroom, if 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, unless otherwise indicated.

D. Install plumbing 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.

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

F. Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.

G. Do not install equipment or piping over electrical gear, electrical panels, motor controllers, and similar electrical equipment. Install equipment and piping to maintain clear space above and in front of all electrical components per the National Electric Code.

3.2. SUPPORTS, HANGERS AND FOUNDATIONS

A. Provide supports, hangers, braces, attachments and foundations required for the work. Support and set the work in a thoroughly substantial and workmanlike manner without placing strains on materials, equipment, or building structure, submit shop drawings for approval. Coordinate all work with the requirements of the structural division.

B. Supports, hangers, braces, and attachments shall be standard manufactured items or fabricated structural steel shapes. All interior hangers shall be galvanized or steel with rust inhibiting paint. For un-insulated copper piping provide copper hanger to prevent contact of dissimilar metals. All exterior hangers shall be constructed of stainless steel utilizing stainless steel rods, nuts, washers, bolts, etc.

C. Concrete housekeeping pads and foundations shall be not less than 4 inches high and shall extend a minimum of 6 inches beyond equipment bases. Provide wire-mesh reinforcement; chamfer exposed edges and corners; and finish exposed surfaces smooth.

3.3. DEMONSTRATION AND TRAINING VIDEO RECORDINGS

A. General: Record demonstration and training video recordings. Record each training module separately.

1. At beginning of each training module, record each chart containing learning objective and lesson outline.

B. Video Recording Format: Provide high-quality color video recordings with menu navigation in format acceptable to Engineer

C. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to show area of demonstration and training. Display continuous running time.

D. Narration: Describe scenes on video recording by audio narration by microphone while video recording is recorded. Include description of items being viewed.

E. Transcript: Provide a transcript of the narration. Display images and running time captured from videotape opposite the corresponding narration segment.

3.4. PROVISIONS FOR ACCESS

A. The contractor shall provide access panels and doors for all concealed equipment, valves, strainers, dampers, filters, controls, control devices, cleanouts, traps, and other devices requiring maintenance, service, adjustment, balancing or manual operation.

B. Where access doors are necessary, furnish and install manufactured painted steel door assemblies consisting of hinged door, key locks, and frame designed for the particular wall or ceiling construction. Properly locate each door. Door sizes shall be a minimum of 12 inches x 12 inches for hand access, 18 inches x 18 inches for shoulder access and 20 inches x 30 inches for full body access where required. Review locations and sizes with Architect prior to fabrication. Provide U.L. approved and labeled access doors where installed in fire rated walls or ceilings. Doors shall be Milcor Metal Access Doors as manufactured by Inland-Ryerson, Mifab, Acudor Products, Babcock-Davis, Nystrom, or approved equal.

1. Acoustical or Cement Plaster: Style B
2. Hard Finish Plaster: Style K or L
3. Masonry or Dry Wall: Style M

C. Where access is by means of liftout ceiling tiles or panels, mark each ceiling grid using small color-coded and numbered tabs. Provide a chart or index for identification. Place markers within ceiling grid not on ceiling tiles.

D. Access panels, doors, etc. described herein shall be furnished under the section of specifications providing the particular service and to be turned over to the pertinent trade for installation. Coordinate installation with installing contractor. All access doors shall be painted in baked enamel finish to match ceiling or wall finish.

E. Submit shop drawings indicating the proposed location of all access panels/doors. Access doors in finished spaces shall be coordinated with air devices, lighting and sprinklers to provide a neat and symmetrical appearance.

F. Where access doors are installed in wet locations (i.e. shower rooms, toilet rooms, kitchen rooms, kitchens, dishwasher rooms, and similar spaces, etc.) provide aluminum access doors/frame.

3.5. PAINTING AND FINISHES

A. Provide protective finishes on all materials and equipment. Use coated or corrosion-resistant materials, hardware and fittings throughout the work. Paint bare, untreated ferrous surfaces with rust-inhibiting paint. All exterior components including supports, hangers, nuts, bolts, washers, vibration isolators, etc. shall be stainless steel.

B. Clean surfaces prior to application of insulation, adhesives, coatings, paint, or other finishes.

C. Provide factory-applied finishes where specified. Unless otherwise indicated factory-applied paints shall be baked enamel with proper pretreatment.

D. Protect all finishes and restore any finishes damaged as a result of work under Division 22 to their original condition.

E. The preceding requirements apply to all work, whether exposed or concealed.

F. Remove all construction marking and writing from exposed equipment, piping and building surfaces. Do not paint manufacturer's labels or tags.

G. All exposed piping, equipment, etc. shall be painted. Colors shall be as stated in this division or as selected by the Architect and conform to ANSI Standards.

H. All exterior roof mounted equipment, piping and vents shall be painted to match roof in color as selected by Architect.

I. All exposed piping, equipment, etc. in finished spaces shall be painted. Colors shall be as selected by the Architect and conform to ANSI Standards.

J. All exposed piping, equipment, etc., in Mechanical Rooms, Penthouses, Fire Pump Rooms, Mezzanines, Crawlspaces, and Storage where PVC jacketed shall not require painting. Label and identify and color code as specified.

K. Paint the perimeter of all housekeeping pads and inertia bases safety yellow.

3.6. CLEANING OF SYSTEMS

A. Thoroughly clean systems after satisfactory completion of pressure tests and before permanently connecting fixtures, equipment, traps, strainers, and other accessory items. Blow out and flush piping until interior surfaces are free of foreign matter.

B. Flush piping in re-circulating water systems to remove cutting oil, excess pipe joint compound, solder slag and other foreign materials. Do not use system pumps until after cleaning and flushing has been accomplished to the satisfaction of the Engineer. Employ chemical cleaners, including a non-foaming detergent, not harmful to system components. After cleaning operation, final flushing and refilling, the residual alkalinity shall not exceed 300 parts per million. Submit a certificate of completion to Engineer stating name of Service Company used.

C. Maintain strainers and dirt pockets in clean condition.

D. Pay for labor and materials required to locate and remove obstructions from systems that are clogged with construction refuse after acceptance. Replace and repair work disturbed during removal of obstructions.

E. Leave systems clean, and in complete running order.

3.7. COLOR SELECTION

A. Color of finishes shall be as selected by the Architect.

B. Submit color of factory-finished equipment for acceptance prior to ordering.

3.8. PROTECTION OF WORK

A. Protect work, material and equipment from weather and construction operations before and after installation. Properly store and handle all materials and equipment.

B. Cover temporary openings in piping and equipment to prevent the entrance of water, dirt, debris, or other foreign matter. Deliver pipes and tubes with factory applied end caps.

C. Cover or otherwise protect all finishes.

D. Replace damaged materials, devices, finishes and equipment.

E. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, where stored inside.

3.9. OPERATION OF EQUIPMENT

A. Clean all systems and equipment prior to initial operation for testing, balancing, or other purposes. Lubricate, adjust, and test all equipment in accordance with manufacturer's instructions. Do not operate equipment unless all proper safety devices or controls are operational. Provide all maintenance and service for equipment that is authorized for operation during construction.

B. Where specified, or otherwise required, provide the services of the manufacturer's factory-trained servicemen or technicians to start up the equipment. Where factory start-up of equipment is not specified, provide field start-up by qualified technician.

C. Submit factory start-up sheets or field start-ups sheets for all equipment prior to the commencement of testing and balancing work. Testing and balancing work shall not commence until start-up reports have been completed, reviewed by Engineer and forwarded to Testing and Balancing Agency.

D. Do not use plumbing systems for temporary services or temporary conditioning during construction. Refer to Division 01 section "Temporary Facilities and Controls" for temporary plumbing during construction.

E. Upon completion of work, clean and restore all equipment to new conditions; replace expendable items such as filters.

3.10. IDENTIFICATIONS, FLOW DIAGRAMS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS

A. Contractor shall submit for approval schematic piping diagrams of each piping system installed in the building. Diagrams shall indicate the location and the identification number of each valve in the particular system. Following approval by all authorities, the diagrams shall be framed, mounted under safety glass and hung in each Mechanical Room where directed. Contractor shall deliver the tracing or sepia from which the diagrams were reproduced to the Owner.

B. All valves shall be plainly tagged. For any bypass valves, install sign indicating valve position as “Normally Open” or “Normally Closed” as required.

C. All items of equipment, including motor starters and disconnects shall be furnished with white on black plastic permanent identification cards. Lettering shall be a minimum of ¼ inch high. Identification plates shall be secured, affixed to each piece of equipment, starters, disconnects, panels by screw or adhesive (tuff bond #TB2 or as approved equal).

Equipment identification and room name or area served shall be on each panel.

D. Provide six (6) copies of operating and maintenance instructions for all principal items of equipment furnished. This material shall be bound as a volume of the Operations and Maintenance Manuals as hereinafter specified.

E. All lines piping installed under this contract shall be stenciled with direction of flow arrows and with stenciled letters naming each pipe and service. Refer to Division 22 Section, Plumbing Piping, Fittings, Valves, Etc. Color code all direction of flow arrows and labels. In finished spaces omit labeling and direction of flow arrows. Paint in color as selected by Architect.

F. Submit list of wording, symbols, letter size, and color coding for plumbing identification. Submit samples of equipment identification cards, piping labels, labels, and valve tags to Engineer for review prior to installation.

G. Provide at least 16 hours of straight time instruction to the operating personnel. Time of instruction shall be designated by the Owner. Additional instruction time for the automatic temperature control (ATC) system is specified in Division 23 Section, Instrumentation and Controls of HVAC and Plumbing Systems.

H. Contractor shall demonstrate Sequences of Operation of all plumbing equipment in presence of Owner's representative, Engineer, and ATC subcontractor.

3.11. WALL AND FLOOR PENETRATION

A. All penetrations of partitions, ceilings, roofs and floors by piping or conduit under Division 22 shall be sleeved, sealed, and caulked airtight for sound and air transfer control. Penetrations of mechanical room partitions, ceilings, and floors shall be as specified in Division 07 Section, "Fire Protection, HVAC and Plumbing Penetration Firestopping".

B. All penetration of fire rated assemblies shall be sleeved, sealed, caulked and protected to maintain the rating of the wall, roof, or floor. Fire Marshal approved U.L. assemblies shall be utilized. See Division 07 Section, "Fire Protection, HVAC and Plumbing Penetration Firestopping".

C. Where piping extends through exterior walls or below grade, provide waterproof pipe penetration seals, as specified in another division of these specifications.

D. Provide pipe escutcheons for sleeved pipes in finished areas.

E. Piping sleeves:

1. Galvanized steel pipe, standard weight where pipes are exposed and roofs and concrete and masonry walls. On exterior walls provide anchor flange welded to perimeter.
2. Twenty-two (22) gauge galvanized steel elsewhere.

F. Extend all floor sleeves through floor at least 2-inches above finished floor, caulk sleeve the entire depth and furnish and install floor plate.

G. Sleeves for penetrations in kitchen and food service areas shall finish .375 inches above floor or flush with wall surfaces and be neatly pointed up to fit snuggly against floor or wall material.

3.12. RECORD DRAWINGS

A. Upon completion of the mechanical installations, the Contractor shall deliver to the Architect one complete set of prints of the mechanical contract drawings which shall be legibly marked in red pencil to show all changes and departures of the installation as compared with the original design. They shall be suitable for use in preparation of Record Drawings.

B. Contractor shall incorporate all sketches, addendums, value engineering, change orders, etc., into record drawings prior to delivering to Architect.

3.13. WARRANTY

A. Contractor's attention is directed to warranty obligations contained in the General Conditions and Supplementary Conditions.

B. The above shall not in any way void or abrogate equipment manufacturer's guarantee or warranty. Certificates of equipment manufacturer’s warranties shall be included in the operations and maintenance manuals.

C. The contractor guarantees for a two (2) year period from the time of final acceptance by the Owner.

1. That the work contains no faulty or imperfect material or equipment or any imperfect, careless, or unskilled workmanship.
2. That all work, equipment, machines, devices, etc. shall be adequate for the use to which they are intended, and shall operate with ordinary care and attention in a satisfactory and efficient manner.
3. That the contractor will re-execute, correct, repair, or remove and replace with proper work, without cost to the Owner, any work found to be deficient. The contractor shall also make good all damages caused to their work or materials in the process of complying with this section.
4. That the entire work shall be water-tight and leak-proof.

3.14. LUBRICATION

A. All bearings, motors, and all equipment requiring lubrication shall be provided with accessible fittings for same. Before turning over the equipment to the Owner, the Contractor shall fully lubricate each item of equipment, shall provide one year's supply of lubricant for each, and shall provide Owner with complete written lubricating instructions, together with diagram locating the points requiring lubrication. Include this information in the Operations and Maintenance Manuals.

B. In general, all motors and equipment shall be provided with grease lubricated roller or ball bearings with Alemite or equal accessible or extended grease fittings and drain plugs.

3.15. OPERATIONS AND MAINTENANCE MANUALS

A. The Contractor shall have prepared six (6) hardcopies and one (1) electronic copy of the Operations and Maintenance Manuals and deliver these copies of the manuals to the Owner. The manuals shall be as specified herein. The manuals must be approved and will not be accepted as final until so stamped.

B. The manuals shall be bound in a three ring loose-leaf binder similar to National No. 3881 with the following title lettered on the front: Operations and Maintenance Manual Smyrna School District – Sunnyside Intermediate School – Plumbing Systems. No sheets larger than 8-1/2 inches x 11 inches shall be used, except sheets that are neatly folded to 8-1/2 inches x 11 inches and used as a pull-out. Provide divider tabs and table of contents for organizing and separating information.

C. Electronic copies of the manual shall be saved on USB flash drives, and shall be in searchable PDF format with interactive index tabs. Approved electronic copies shall be stored in flash drive zipper cases in front of Volume 1 (if applicable) of hard copies of the manual.

D. Provide the following data in the booklet:

1. As first entry, an approved letter indicating the starting/ending time of Contractor's warranty period.
2. Catalog data on each piece of plumbing equipment furnished.
3. Maintenance operation and lubrication instructions on each piece of plumbing equipment furnished.
4. Complete catalog data on each piece of plumbing equipment furnished including approved shop drawing.
5. Manufacturer's extended limited warranties on equipment.
6. Chart form indicating frequency and type of routine maintenance for all plumbing equipment. The chart shall also indicate model number of equipment, location and service.
7. Provide sales and authorized service representatives names, address, and phone numbers of all equipment and subcontractors.
8. Provide supplier and subcontractor's names, address, and phone number.
9. Catalog data of all equipment, valves, etc. shall include wiring diagrams, parts list and assembly drawing.
10. Provide and install in locations as directed by the Owner, valve charts including valve tag number, valve type, valve model number, valve manufacturer, style, service and location. Each valve chart shall be enclosed in a durable polymer based frame with a cover safety glass. .
11. Copy of the approved balancing report for plumbing equipment/system.
12. Access panel charts with index illustrating the location and purpose of access panels.
13. Approved Health and Plumbing and Electrical Certificates.
14. Start-up reports for equipment.
15. Insert color graphic with embedded parameters for ATC system into Record and Information Booklet.

E. Electronic copies of the manual shall be saved on USB flash drives, and shall be in searchable PDF format with interactive index tabs. Approved electronic copies shall be stored in flash drive zipper cases in front of volume 1 (if applicable) of hard copies of the manual.

F. Submit Operations and Maintenance Manuals prior to the anticipated date of substantial completion for Engineer review and approval. Substantial completion requires that Operations and Maintenance Manuals are reviewed and approved.

3.16. INSTALLATION AND COORDINATION DRAWINGS

A. Prepare, submit, and use composite installation and coordination drawings to assure proper coordination and installation of work. Drawings shall include, but not be limited, to the following:

1. Complete Plumbing, Sprinkler and HVAC Piping Drawings showing coordination with lights, electrical equipment, HVAC equipment and structural amenities.

B. Draw plans to a scale not less than 3/8-inch equals one foot. Include plans, sections, and elevations of proposed work, showing all equipment, and piping in areas involved. Fully dimension all work including lighting fixtures, conduits, pullboxes, panelboards, and other electrical work, walls, doors, ceilings, columns, beams, joists and other architectural and structural work.

C. Identify all equipment and devices on wiring diagrams and schematics. Where field connections are shown to factory-wired terminals, include manu¬facturer's literature showing internal wiring.

3.17. PIPING SYSTEMS TESTING

A. The entire new plumbing piping systems shall be tested hydrostatically before insulation covering is applied and proven tight under the following gauge pressures for a duration of twenty-four (24) hours. Testing to be witnessed by Owner's representative and documented in writing.

SYSTEM	**TEST PRESSURE**
Domestic Water & Coil Drain Piping	100 psig
Sanitary & Storm Water Piping	As specified below

B. All gas piping shall be pressure tested in accordance with NFPA-54, and NFPA-58. Gas piping systems shall be proven tight under the following gauge pressures for a duration of four (4) hours:

SYSTEM	**TEST PRESSURE**
Gas Piping	100 psig

C. All storm, waste, vent and water piping shall be tested by the Contractor and approved by the Engineer before acceptance. All storm, soil, and waste piping, located underground, shall be tested before backfilling. The costs of all equipment required for tests are to be included in the contract price.

D. The entire new drainage system and venting system shall have all necessary openings plugged and filled with water to the level of the highest stack above or at the roof. The system shall hold this water for thirty (30) minutes without showing a drop greater than 1inch. Where a portion of the system is to be tested, the test shall be conducted in the same manner as described for the entire system, except a vertical stack 10 feet above the highest horizontal line to be tested may be installed and filled with water to maintain sufficient pressure, or a pump may be used to supply the required pressure. The pressure shall be maintained for thirty (30) minutes. All testing shall be in accordance with the local Plumbing Code and witnessed by the Plumbing Inspector or authority having jurisdiction.

E. Upon completion of roughing-in and before setting equipment and fixtures, the entire new water piping system shall be tested at a hydrostatic pressure of not less than one hundred (100) pounds per square inch gauge and proven tight at this pressure. Where a portion of the water piping system is to be concealed before completion, this portion shall be tested separately in a manner described for the entire system.

F. Testing and acceptance thereof shall be in accordance with local requirements and shall meet approval of authority having jurisdiction. Submit certificates and approved permits and insert one (1) copy in the Operations and Maintenance Manuals.

3.18. EQUIPMENT BY OTHERS

A. This Contractor shall make all system connections required to equipment furnished and installed under other divisions or furnished by the Owner. Connections shall be complete in all respects to render this equipment functional to its fullest intent.

B. It shall be the responsibility of the supplier of this equipment to furnish complete instructions for connections. Failure to do so will not relieve this contractor of any responsibility for improper equipment operation.

END OF SECTION

OUTAGE REQUEST

DATE APPLIED: ___________________________BY: ______________________________________

DATE FOR OUTAGE: __________________________ FIRM: ____________________________

START OUTAGE-TIME: ________________________ DATE:____________________________

END OUTAGE -- TIME: _________________________ DATE:____________________________

AREAS AND ROOMS: ____

FLOOR(S): ____

AREA(S): ____

ROOM(S): ____

WORK TO BE PERFORMED: ____

SYSTEM(S): ____

REQUEST APPROVED BY: ____

(FOREMAN OR OTHER PERSON IN CHARGE)

(FOR OWNER'S USE ONLY):

APPROVED: ____

YES _____ NO ____ BY: _________________________________DATE: ___________________________

DATE/TIME-AS REQUESTED: ________________ OTHER : _________________________

OWNER'S PRESENCE REQUIRED: ____

YES: ____ NO: ____ NAME: ____

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DIVISION 22 SECTION 22 05 05
PLUMBING PIPING, FITTINGS & VALVES
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SECTION 22 05 05 - PLUMBING PIPING, FITTINGS AND VALVES

PART 1. GENERAL

1.1. SUMMARY

A. The conditions of the contract and other general requirements apply to the work specified in this section. All work under this section shall also be subject to the requirements of Division 22 Section, Common Work Results for Plumbing and Division 01, General Requirements.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SYSTEM DESCRIPTION CONDITIONS

A. Provide all labor and materials necessary to furnish and install all piping systems on this project as herein specified and/or shown on the drawings. Final connections to equipment furnished in other sections of the specifications shall be included under this section.

B. All piping and insulation installed in ceiling plenums must be plenum rated and comply with NFPA and International Building Code (IBC).

C. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

D. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.

E. Use non-conducting dielectric connections whenever jointing dissimilar metals in open systems.

F. Provide pipe hangers and supports in accordance with ASTM B31.9 and MSS SP69 unless indicated otherwise.

G. Use spring loaded "silent" check valves on discharge of all pumps.

H. Use 3/4 inch (20 mm) ball valves with cap and chain for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest floor drain.

I. At all runout piping serving equipment, use swing joints with elbows to prevent excessive movement of piping due to expansion.

1.3. QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body.

B. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulation. Provide certificate of compliance from authority having jurisdiction indicating approval of welders.

C. Welders Certification: In accordance with ASME Section 9.

D. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

E. All castings used for coupling housings, fittings, and valve bodies shall be date stamped for quality assurance and traceability.

F. Maintain one copy of each document on site.

1.4. DELIVERY, STORAGE AND HANDLING

A. Deliver, store, protect and handle products to site under as hereinbefore specified.

B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

C. Provide temporary protective coating on cast iron and steel valves.

D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed systems.

1.5. ENVIRONMENTAL REQUIREMENTS

A. Do not install underground piping when bedding is wet or frozen.

1.6. EXTRA MATERIALS

A. Provide one (1) repacking kit for each size valve.

1.7. ALTERNATES

A. Refer to Division 01 Section, “Alternates” for description of work under this section affected by alternates.

1.8. LEAD FREE REQUIREMENTS

A. All plumbing fixtures, equipment, and devices that contact potable water must be lead free per the State requirements.

1.9. PLASTIC PIPE PENETRATIONS

A. Install UL listed collars, sealing methods, and firestopping at all plastic pipe penetrations of smoke walls and fire rated walls per NFPA.

PART 2. PRODUCTS

2.1. PIPE MATERIALS

A. All materials, unless otherwise specified, shall be new and of the best quality of their respective kinds, and shall conform to the requirements and ordinances of local, state and insurance authorities having jurisdiction.

1. Sanitary Underground - Within Building to 5 Feet Outside of Foundation Wall:

a. PVC Pipe: Schedule 40 DWV or cellular core. Fittings: Schedule 40 PVC, ASTM D 2665 or ASTM F891 socket fittings. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.

2. Sanitary and Vents Above Floor Inside Building:

a. PPVC Pipe: Schedule 40 DWV or cellular core. Fittings: Schedule 40 PVC, ASTM D 2665 or ASTM F891 socket fittings. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.

3. Indirect Waste Piping:

a. Pipe & Fittings: Hard drawn Type L copper tubing with cast brass drainage fittings. ASTM B88-78 and ANSI B16.1877. All exposed indirect waste piping shall be chrome plated or primed and painted with silver paint.

4. Storm Water Below Grade or Under Building to Point 5 Feet from Building Line:

a. PVC Pipe: Schedule 40 DWV or cellular core. Fittings: Schedule 40 PVC, ASTM D 2665 or ASTM F891 socket fittings. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.

5. Storm Water Above Floor Inside Building:

a. PPVC Pipe: Schedule 40 DWV or cellular core. Fittings: Schedule 40 PVC, ASTM D 2665 or ASTM F891 socket fittings. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.

6. Domestic Cold Water Outside of Building Below Ground or Under Building to Point 5 Feet from Building Line:

a. Pipe: 2-1/2 inches & smaller, soft temper type K. ASTM B88 - No joints below grade except as approved by the Engineer.
3 inches & larger, ductile iron pipe for water, ANSI 21.50 & 21.51 with double thickness cement mortar lining, ANSI 21.4.

b. Fittings & Joints: wrought copper solder joint fittings, ANSI B16.22. Joints for copper piping shall be ASTM B32, SOLDER, grade 95TA.
Cast iron pressure fittings, ANSI 21.10, Class 250. Mechanical specification for mechanical joint for cast iron pressure pipe & fittings ANSI A21.11. Joints for ductile iron pipe shall be AWWA C111, rubber

gasket with 3/4 inch diameter rods.

7. Domestic Hot, Cold and Re-circulating Water Piping Inside Buildings, Above Grade:

   a. Pipe: All domestic water piping shall be PEX-A plastic according to ASTM F876, ASTM F877, ANSI/NSF Standard 61. Acceptable manufacturers are Uponor (Basis of Design) or approved equal.

      i. Fittings: ASTM F1807, metal insert and copper crimp rings; ASTM F1960, cold expansion fittings and reinforcing rings. ASSE 1061, push-fit fittings.

      ii. Manifold: Multiple-outlet, plastic or corrosion-resistant-metal assembly complying with ASTM F876; with plastic or corrosion-resistant-metal valve for each outlet.

      iii. All materials, installation, storing & handling shall be per manufacturer's recommendations and requirements for a full turnkey system.

   b. Install fire stopping per Fire Marshall requirements.
   c. Install and size thermal expansion loops per pipe manufacturer’s requirements.

8. Gas Piping:

   a. Pipe: Inside Building Above Ground: Schedule 40 uncoated black steel pipe, ASTMA 53 or A120.
   b. Outside Building, Below Ground: Copper type L tubing, ASTM B88 Below Ground.
   c. Outside building above grade/roof: Schedule 40 black steel pipe, ASTM A53 or A120.
   d. Fittings & Joints: 150 lb. screwed malleable iron ASTM B16.3 with joints sealed with litharge and glycerin. Piping 2 ½ inches and larger and any concealed piping within walls must be welded, ASTM A24 forged steel welded type joints shall be threaded or welded to ANSI B31.1 or ASME Sec. 1.
   e. Plug Valves: 2- ½ inches & larger ASME B16.38 and MSS SP-78 cast iron lubricated plug valves with 125 psig pressure rating, 3 turn type. Gas valves are prohibited above ceilings.
   f. Cocks: 2 inches& smaller - bronze, Crane 270. AGA certified bronze body, plug type with bronze plug, ball type with chrome plated brass ball, for 5 psig or less gas. Include AGA stamp, flat or square head or lever handle, and threaded ends conforming to ASME B1.20.1
   g. Ball Valves: Full flow, double seal, ball type with bronze body, Buna-N seals and O-ring packing, chrome plated brass ball and designed for working pressures up to 175 psig. Valves shall be 3 turn type. MSS SP-78, class 175 WOG.
   h. Gas Vents: Install vent piping for gas pressure regulators and gas trains, extend outside building to a non-hazardous location away from any

potential source of ignition, and vent to atmosphere. Pipe material shall be identical to gas piping here-in before specified. Terminate vents with turned down, reducing elbow fittings with corrosion-resistant insect screen in large end.

i. Finish: All gas piping downstream of regulator, installed exposed in a kitchen, or piping installed on a roof shall be primed and finished with two coats of rust resistant paint with pewter gray finish. Paint shall be two part epoxy-exterior paint as manufactured by Pittsburgh Paint, Themeco, or approved equal. Painting shall be provided under another Section of these Specifications.

j. Combination Shut-off/Balancing Valves:

  i. Victaulic/TA Hydronics, Taco Circuit Setter, Bell & Gossett Circuit Setter Plus, Flowset Accuset, Gerand, or engineer approved equal, ½ inch-3 inches 300 psi rated globe type or ball valve with DZR brass Ametal (copper-alloy) or bronze body/brass ball construction with glass and carbon filled TFE seats, in-line flow meter and balancing and shut-off valve with built in ball valve for flow adjustment. Valve shall have memory stop, calibrated nameplate, Schrader valve connections and preformed molded insulation. Valves shall be leaktight at full rated working pressure. Balance valve size shall be selected based on manufacturer's acceptable flow range and design flow rate. Pressure drop through combination shut off balance valves shall not exceed 5 feet of head at design flow rate. Where required for flow rates below 0.6 GPM, provide "reduced flow" combination shut-off balance valves sized so that the flow rate is within the manufacturer's recommended flow range.

k. Extended Valve Stems: Provide and install round collar type extended valve stems on all valves installed in insulated piping. Valve stem and collar shall be selected to suit insulation thickness and maintain valve handles outside of insulation.

9. Elevator Sump Pump Discharge Piping:

  a. Piping: CPVC Plastic Pipe, ASTM 441, Schedule 80, plain ends.
  b. Fittings and Joints: CPVC plastic pipe fittings, socket type fittings, ASTMF 439 for Schedule 80 pipe.
  c. Basis of Design: Victaulic Series 318 Sump Ejector
  d. Shut-off Valves: 150 psig working pressure, 150 degree F maximum operating temperature, full port design 2 piece body design, CPVC body and ball, polytetrafluoroethylene seats, EPDM seals, tee handle, with threaded socket union, or flanged connections.
  e. Cement: CPVC solvent cement: ASTM F493.

10. Gas Fired Condensing Water Heater Condensate Piping

  a. Piping shall be PVC pipe, ASTM D1785 schedule 40 with ASTM D2466 socket fittings for schedule 40. Join PVC pipe/fittings utilizing solvent cement ASTM D2564 with ASTM F 656 primer.

b. Provide backwater valve (ball float type) at connections of condensate piping to stormwater piping and air gap fitting. Backwater valve shall be Model Z1099 as manufactured by Zurn or approved equal. Backwater valve shall have drain coated cast iron body, plastic ball float, bronze backwater bushing and replaceable neoprene seat.

B. Steel pipe shall be similar and equal to National Tube Company, Grinnell, Republic, or Bethlehem black or zinc-coated (galvanized) as hereinafter specified. Pipe shall be free from all defects which may affect the durability for the intended use. Each length of pipe shall be stamped with the manufacturer's name.

C. Copper pipe shall be Revere, Anaconda or Chase with approved solder fittings.

D. Welding fittings for steel pipe shall meet the requirements of ASTM Standard A-23 and shall be standard catalog products. Fittings fabricated by metering and notching pipe will not be accepted.

2.2. PIPE HANGERS, ROLLER SUPPORTS, ANCHORS, GUIDES, AND SADDLES

A. All hangers for metallic piping shall be adjustable, wrought clevis type, or adjustable malleable split ring swivel type, having rods with machine threads. Hangers shall be Grinnell Company's Figure 260, Carpenter and Patterson, or approved equal for pipe ¾-inch and larger, and Figure 65 for pipe 2-inches and smaller, or approved equal. Adjustable pipe stanchion with U-bolt shall be Grinnell Company's Figure 191. Pipe roller supports shall be Grinnell's Figure 181 or Figure 271. Exterior pipe hangers shall be galvanized or stainless steel construction. For copper piping in direct contact with the hanger, hanger construction shall be copper coated to prevent contact of dissimilar metals similar to Grinnell's Figure CT-65. Hanger spacing and rod sizes for steel and copper pipe shall not be less than the following:

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
3/4 & 1	6	5	3/8
1 - ½	6	8	3/8
2	8	8	3/8

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
2 – ½	10	9	½
3	12	10	½
4	14	12	5/8
5	14	12	5/8
6	16	14	3/4
8	18	16	7/8
10	20	18	7/8
12	20	18	7/8

B. Install hangers for storm water and 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): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
3. PS 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.

6. NPS 15 (DN 375): 48 inches (1200 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).

C. Install supports for vertical soil piping every 4 feet (1200 mm).

D. Install hangers for Uponor piping with the following maximum horizontal spacing and minimum rod diameter:

1. NPS 1 (DN 25) and Smaller: 36 inches (900mm) 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 ½ to NPS 3 ½ (DN 65 to DN 90): 48 inches (1200 mm) with ½ 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): 48 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.

E. Install supports for Uponor 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.

F. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters.

G. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 ½ and NPS 2 (DN and DN 50): 48 inches (1200 mm) with 3/8 inch (10-mm) rod.
2. NPS 3 (DN 80): 48 inches (1200 mm) with ½ 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

H. Install supports for vertical PVC piping every 48 inches (1200 mm).

I. Anchors, guides, and roller supports shall be installed in accordance with the contract drawings and manufacturer's recommendations to provide pipe support and control pipe movement for all piping systems. Anchors and guides shall be securely attached to the pipe support structure. Submit shop drawing for proposed pipe support structure for guides and anchors for approval of the Structural Engineer. Pipe alignment guides shall be Fig. 255 Grinnell, or as approved equal. Guides shall be sized to accommodate the pipe with insulation. Guides shall be steel factory, fabricated, with bolted two section outer cylinder and base for alignment of piping and two section guiding spider for bolting to pipe.

J. Hangers for pipe sizes ½ to 1 ½ inch (13 to 38 mm): Carbon steel, adjustable swivel, split ring.

K. Hangers for cold pipe sizes 2 inches (50 mm) and over: Carbon steel, adjustable, clevis.

L. Hangers for cold pipe sizes 2 to 4 inches (50 to 100 mm): Carbon steel, adjustable, clevis.

M. Hangers for cold pipe sizes 6 inches (150 mm) and over: adjustable steel yoke, cast iron roll, double hanger.

N. Multiple or Trapeze hangers: Steel channels with welded spacers and hanger rods.

O. Multiple or Trapeze hangers for hot pipe sizes 6 inches (150 mm) and over: Steel channels with welded spacers and hanger rod, cast iron roll.

P. Wall support for pipe sizes to 3 inches (76 mm): cast iron hook

Q. Wall support for pipe sizes 4 inches (100 mm) and over: Welded steel bracket and wrought steel clamp.

R. Wall support for hot pipe sizes 6 inches (150 mm) and over: welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.

S. Vertical Support: Steel riser clamp.

T. Floor support for cold pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

U. Floor support for hot pipe sizes to 4 inches (100 mm): Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

V. Floor support for hot pipe sizes 6 inches (150 mm) and over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.

W. Copper pipe support: Carbon steel ring, adjustable, copper plated.

X. Hanger rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

Y. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

Z. For Pipe Hangers installed in corrosive environments such as chemical storage rooms the same shall (including hardware) shall be finished with on Electro-Galvanized Finish such as Galv-Krom® or approved equal.

2.3. VALVES

A. Provide parts list and assembly drawings (exploded view) for all valves in shop drawing submittals. Provide valves of the same type by the same manufacturer.

B. Check valves in base mounted pump discharges shall be of the vertical type and shall be Miller "non-slam" check valves or approved equal suitable for service intended. Check valves in circulator discharges shall be horizontal type.

C. Provide at each base mounted pump a suction diffuser of size and type shown on drawings. Units shall consist of a cast iron angle type body with inlet vanes, magnetic insert, and blowdown connection tapped gauge post, 125 psi ANSI flange and a combination stainless steel diffuser strainer with 3/16-inch diameter opening for pump protection. Unit shall be equipped with a disposable fine mesh start up strainer which shall be removable after 30 days. Flow direction shall be from inside the strainer to outside for ease of service and cleaning. The body shall fit the pump and connecting pipe size. The unit shall be provided with an adjustable support foot to relieve piping strains from the pump suction. Suction diffuser shall be Taco "SD" Series Catalog 300-4.1, Bell and Gossett Model FLG, Armstrong, or approved equal.

D. Multi-purpose valve (non-slam check valve, throttling valve, shut-off valves and calibrated balancing valve) shall be provided at discharge side of each constant speed pump. The valve shall be of heavy-duty cast iron construction with standard ANSI flanged connections and rated for a maximum working pressure of 175 psig at 240°F. The valve shall be fitted with a stainless steel stem or stem sleeve and brass seat with "O" ring seal. Valve shall be Taco "Plus One" Number 300-4.2, Bell and Gossett 3DS Triple Duty Valve, Armstrong, or as approved equal, and shall have check and plug valve features plus a memory stop with pointer and scale. Provide additional shut-off valve to allow servicing of check valve if a multipurpose valve is utilized in lieu of separate check, shut-off, and balance valve. Provide additional shut-off valve downstream of multi-purpose valve to allow servicing of multi-purpose check valve feature. Provide pre-manufactured, removable insulation covers for all multipurpose valves.

E. For variable speed pumps do not utilize multipurpose valves. For variable speed pumps install separate shut-off valve and check valve.

2.4. BACKWATER VALVE:

A. Provide backwater valves for all floor drains, A/C condensate drains, and foundation drains connecting directly to the storm water system and where indicated on drawings. Backwater valves shall be constructed of coated cast-iron body, hub inlet and offset spigot outlet, bronze bolted cover, automatic type valve seat and flapper which remains closed during periods of non-operation. Provide RectorSeal Clean Check extendable backwater valves for underslab/below-grade condensate lines as indicated on drawings.

B. Extend access cover to finished floor and terminate in an adjustable floor cleanout as specified hereinbefore.

1. Josam Back Water Valve
2. Zurn Series No. Z1095-FC
3. Jay R. Smith Series No. Fig. 7012

2.5. STRAINERS

A. Strainers shall be of the basket or "Y" type and shall be heavy and durable, constructed of best grade gray iron with the bottoms drilled and plugged. Bodies shall have arrows clearly cast on the sides to show flow direction. Strainers shall be equipped with easily removable covers and brass sediment baskets made of brass not less than #22 gauge in thickness. Total area of basket perforations shall be not less than four times the cross section of the entering pipe. Flow shall be into basket, and then out through the perforations. Strainers shall be suitable for water or the intended fluid. Strainers 2 inches and smaller shall have threaded or solder ends, 2 inches and larger shall have flanged ends.

B. Strainer screens shall be stainless steel with perforations and shall be 1/16-inch for pipe sizes 5 inches and less, 1/8-inch (40 percent open area) perforations for pipe sizes 6-inch and greater.

C. Provide valved and capped (with chain) blowdowns in each strainer. Blowdown valves shall be Appolo 78-100/200 series or as approved equal.

D. Strainers shall be manufactured by Watts, Mueller, Armstrong, Yarway, Spirax/Sarco or as approved equal.

2.6. UNIONS, FLANGES, AND COUPLINGS

A. Unions in steel pipe 2-inches and smaller shall be malleable iron with brass inserted seats designed for a working pressure of 150 psig.

B. Unions in copper pipe 2-inches and smaller shall be sweat fittings with bronze seats designed for a working pressure of 125 psig.

C. Flanges for steel pipe over 2 inches shall be 150 psig, forged steel, and slip on type. Gaskets shall be 1/16 inch thick pre-formed neoprene.

D. Flanges for copper pipe over 2 inches shall be bronze. Gaskets shall be 1/16 inch thick preformed neoprene.

2.7. MANUAL AIR VENTS

A. Manual air vents shall be similar to the hereinafter specified gauge valves. Provide 1/4-inch size on ¾-inch pipe and smaller, ½ -inch size on 1-inch pipe and larger. Install at all high points of piping. Valves shall be Crane No. 88, Honeywell or as approved equal, with threaded ends, bronze body, bronze or brass bonnet and bronze stem.

2.8. THERMOMETERS

A. Unless otherwise indicated, thermometers shall be ASTM E1, in a glass type, organic filled, 9-inch scale size, corrosion-resistant metal case, with "any-angle" mounting with positive locking device. Trerice Industrial Thermometers, Weksler Instruments, Ernst Gage Co., Miljoco, or approved equal. Insertion stem length shall suite the pipe size and configuration. Thermometer wells shall be brass with brass union hubs in copper and in ferrous piping. Where piping is insulated or otherwise covered, use wells with lagging extension. Where wells are installed in pipe tees at turns, increase pipe size so that well does not restrict flow. Accuracy shall be 2 percent.

B. Unless otherwise indicated, thermometer ranges shall be as follows:

1. Domestic cold water: 0 degrees F to 100 degrees F, 1 degrees F Division.
2. Domestic hot and hot water recirculating: 30 degrees F to 180 degrees F, 2 degrees F Division.
3. Tempered Water: 30 degrees F to 100 degrees F, 2 degrees F Division.

C. Provide heat conducting compound in wells.

2.9. PRESSURE GAUGES

A. Unless otherwise indicated, pressure gauges shall be the bronze bourdon tube type, 4-1/2-inch dial, stem mounting, cast aluminum adjustable pointer, 1 percent accuracy over middle half of scale range, 1-1/2 percent over balance: Trerice Model 600C; Weksler Instruments, Ernst Gage Co., Miljoco, or as approved equal.

B. Gauges shall have pressure, vacuum, compound, or retard ranges as required, select ranges so that the normal readings are at the approximate midpoint and maximum system pressures do not exceed full scale.

C. Furnish and install a gauge valve at each pressure gauge. Gauge valves shall be Crane Model No. 88, Needle Valve, Ernst Gage Co. FLG 200, Wexler Instrument Corp. Type BBV4, or approved equal, rated for pressure intended.

D. Gauge connections for pressure gauges, thermometers, or control instruments shall be made using tee fittings, except that gauge connections up to 1-inch size in steel may be using threaded extra heavy pipe couplings welded directly to the main, provided that the main is at least 2-inch size for 2-inch connections, 3-inch size for 3/4-inch connections, and 4-inch size for 1-inch connections. Minimum gauge connection shall be 2-inch ips.

E. Provide snubbers on all gauges. Snubbers shall be No. 872 by Trerice, RS1/RS6 by Wexler Instruments, Miljoco or as approved equal.

2.10. PIPING SPECIALTIES

A. Furnish and install flexible pipe connections, as specified and/or shown on the drawings, at suction and discharge connections of all base mounted and vertical in-line pumps, connections to booster pumps, all vibrating equipment and elsewhere as shown. Refer to Division 23 Section, Vibration Control for HVAC, Plumbing and Fire Protection Equipment for specifications.

B. Pressure relief valves shall be provided in the number and sizes required to relieve 110 percent of the full input to the systems. Valves shall be rated; and installed in accordance with ASME, and CSD-1 including all amendments. Pipe discharge full size to floor drain, (with union) and support discharge pipe to prevent exerting any strain on relief valve body, piping to be Type-L copper. Water safety relief valves shall be Watts Series 740, Conbraco, Series 154A, Bell and Gossett, or approved equal. Provide pressure gauge adjacent to all safety relief valves.

C. Gas relief valve piping shall be sized and installed in accordance with the latest edition of ASME Boiler & Pressure Vessel Code, CSD-1 including amendments. Pipe material shall be as specified for gas piping. Gas relief valve piping material shall be the same as hereinbefore specified for gas piping. Install stainless steel mesh screen and turndown on all gas relief valve/vent piping terminations.

2.11. ESCUTCHEONS

A. Provide chromium plated escutcheons properly fitted and secured with set screws on all exposed piping which passes through walls, floors or ceilings of finished spaces.

B. All escutcheon plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface. Plastic escutcheon plates will not be accepted.

2.12. DIELECTRIC CONNECTIONS:

A. Furnish and install electrically insulated dielectric unions, waterway fittings, or flanges, as manufactured by Victaulic Company, EPCO Sales, Inc., at the following locations:

1. Where steel piping systems join copper piping.
2. Where copper tube connects to domestic water storage tanks, water heaters, heat exchangers, expansion tanks, and other steel vessels.
3. Avoid the installation of steel nipples, cast iron or steel valves and specialties, or other ferrous components in predominately copper piping systems. Where such installation is necessary, isolate the component with dielectric connections. Do not mix steel pipe and copper tube in the same run of pipe or in the same section of a piping system.
4. Dielectric Waterway: Copper silicon casting conforming to UNS C87850 with grooved and/or threaded ends. UL classified in accordance with NSF-61 for potable water service, and shall meet the low lead requirements of NSF-372. Basis of Design: Victaulic Series 647.

2.13. SLEEVES

A. Sleeves shall be provided around all pipes through walls, floors, ceilings, partitions, roof structure members or other building parts. Sleeves shall be standard weight galvanized iron pipe two sizes larger than the pipe or insulation so that pipe or insulation shall pass through masonry or concrete walls or floors. Provide 20 gauge galvanized steel sheet or galvanized pipe sleeves for all piping passing through frame walls.

B. Sleeves through floors shall be flush with the floor except for sleeves passing through Equipment Rooms which shall extend ¾-inch above the floor. Refer to Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment for mechanical equipment room penetrations additional requirements. Space between the pipe and sleeve shall be caulked. Escutcheon plates shall be constructed to conceal the ends of sleeves. Each trade shall be responsible for drilling existing floors and walls for necessary sleeve holes. Drilling methods and tools shall be as hereinbefore specified.

C. Sleeves through walls and floors shall be sealed with a waterproof caulking compound.

D. Firestop at sleeves that penetrate smoke barriers smoke partitions and/or rated walls/floors.

2.14. PRESSURE REDUCING VALVES

A. Provide pressure reducing valves as indicated, of size and capacity selected by the installer to maintain operating pressure on the system. Body shall be cast-iron or bronze construction, renewable stainless steel seat, non-corrosive disc, water tight cage assembly, adjustable pressure ranges and inlet strainer Watts Regulator Model 223-S, Armstrong, Bell and Gossett or as approved equal. Maximum working pressure shall be 300 psig.

B. Provide pressure gauge adjacent to all pressure reducing valves to verify proper set point.

2.15. WATER PROOF PIPE PENETRATION SEALS

A. Provide and install waterproof pipe penetration seals at all pipes that enter the building below grade or through exterior wall.

B. Link seals are to be Metraflex Metraseals, Model MS, Linkseal, or approved equal, black EPDM seal material, glass reinforced plastic pressure plates, zinc plated nuts and bolts, seals are to be resistant to sunlight and ozone, pressure rated to make a hydrostatic seal of up to 20 psig and up to 40 feet of head, temperature rated from –40 degrees F to 250 degrees F.

2.16. GAS PRESSURE REGULATORS

A. Gas pressure regulators shall be as manufactured by Equimeter, Inc., Maxitrol Co., Rockwell, Fisher Controls, American Meter Co., Pietro Fiorentini, or approved equal. Gas pressure regulators shall maintain a constant downstream pressure with a variable inlet pressure.

B. Gas pressure regulators shall comply with ANSI Z21.18 and shall be single stage, steel jacketed, corrosion-resistant type. Include atmospheric vent, elevation compensator, with threaded ends conforming to ASME B1.20.1 for 2 inch NPS and smaller and flanged ends for 2 ½ inch NPS and larger.

C. Gas pressure regulator shall be a positive lock-up type regulator where required by equipment manufacturer.

D. Each pressure regulator shall have an identification stamped on diaphragm cover and shall be painted AGA grey. Regulator inlet and outlet pressures, and flow volume in cubic feet per hour of specified gas are as indicated on the contract drawings.

E. Install water heater gas pressure regulators a minimum of 3 feet and no more than 8 feet from the water heaters per the manufacturer's requirements.

2.17. EQUIPMENT RUN-OUT FLEXIBLE GAS PIPE CONNECTIONS

A. Description: Comply with AGA LC 1 and include the following:

1. Tubing: Corrugated stainless steel with plastic jacket or coating.
2. Fittings: Copper alloy with ends made to fit corrugated tubing. Include ends with threads according to ASME B1.20.1 if connection to threaded pipe or fittings is required.
3. Striker Plates: Steel, designed to protect tubing from penetrations.
4. Manifolds: malleable iron or steel with protective coating. Include threaded connections according to ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
5. Available Manufacturers:

   a. OmegaFlex, Inc.
   b. Titeflex Corp.

c. Tru-Flex Metal Hose Corp.
d. Ward Industries, Inc.

6. Flexible gas piping shall only be utilized adjacent to equipment. All other gas piping shall be rigid gas piping as specified.

2.18. TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Plastic-to-Metal Transition Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Charlotte Pipe and Foundry Company.
b. Harvel Plastics, Inc.
c. Spears Manufacturing Company.

2. Description: PVC or CPVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert and one solvent-cement-socket end.

D. Plastic-to-Metal Transition Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Colonial Engineering, Inc.
b. NIBCO INC.
c. Spears Manufacturing Company.

2. Description: PVC or CPVC four-part union. Include brass threaded end, solvent-cement-joint plastic end, rubber O-ring, and union nut.

2.19. GAS PIPING SUPPORTS/BASES (NON-PENETRATING)

A. Furnish and install gas piping supports for all piping installed. Entire system shall be as manufactured by Eberl Iron Works or approved equal.

B. Bases: the base supports shall be the non-penetrating type preventing need for additional barriers. Base material shall be heavy duty rubber manufactured from 100% recycled ground crumb rubber.

C. Pipe Supports: The pipe supports shall be elevated pipe roller supports. To allow for expansion and contraction the supports shall include pipe rollers, threaded rods, and supporting hardware. All supports shall be type 304 stainless steel with stainless steel hardware. Furnish with pipe straps to restrain pipes on the rollers.

PART 3. EXECUTION

3.1. GENERAL PIPING INSTALLATION REQUIREMENTS

A. All pipes shall be cut accurately to measurements established at the building, and shall be worked into place without springing or forcing, properly clearing all windows, doors and other openings. Excessive cutting or other weakening of the building structure to facilitate piping installation will not be permitted. All pipes shall be so installed as to permit free expansion and contraction without causing damage. All open ends of pipe lines, equipment, etc., shall be properly capped or plugged during installation to keep dirt or other foreign material out of the system. All pipes shall be run parallel with the lines of the building and as close to walls, columns and ceilings as may be practical, with proper pitch. All piping shall be arranged so as not to interfere with removal of other equipment on devices not to block access to doors, windows, manholes, or other access openings. Flanges or unions, as applicable for the type of piping specified, shall be provided in the piping at connections to all items of equipment, coils, etc., and installed so that there will be no interference with the installation of the equipment, ducts, etc. All valves and specialties shall be placed to permit easy operation and access and all valves shall be regulated, packed and glands adjusted at the completion of the work before final acceptance. All piping shall be installed so as to avoid air or liquid pockets throughout the work. Ends of pipe shall be reamed so as to remove all burrs.

B. All piping shall be graded to convey entrained air to high points where automatic air vents shall be provided. The size of supply and return pipes for each piece of equipment shall in no case be smaller than the outlets in the equipment.

C. All piping shall be run to provide a minimum clearance of 2-inches between finished covering on such piping and all adjacent work. Group piping wherever practical at common elevations.

D. All valves, strainers, caps, and other fittings shall be readily accessible.

E. Rough-in and final connections are required to all equipment and fixtures provided under this Contract.

F. Drain valves with hose connections shall be provided at low points for drainage of piping systems. Blow down valves shall be provided at the ends of all mains and branches so as to properly clean by blowing down the lines throughout in the direction of normal flow.

G. Discharge lines from all relief valves shall be piped to within 4-inches of floor and extend to floor drains wherever floors are not pitched to drains. Pitch the relief valve piping away from the relief valve to issue that no fluid can be trapped in valve discharge. Support all relief valve piping to prevent exerting strain on the relief valve body. The end of the relief valve discharge piping shall not be threaded to prevent capping or plugging.

H. All branches from water mains shall be taken from the top of the supply mains at an angle of forty-five (45) degrees above the horizontal, unless otherwise directed. Branches feeding down shall be taken from the side or bottom of the main on water mains only. All connections shall be carefully made to insure unrestricted circulation, eliminate air pockets or trapped condensate, and permit the complete drainage of the system.

I. Cutoff valves shall be provided on each branch line from the mains on all plumbing lines.

J. Shut-off valves shall be installed at the inlet and outlet of each piece of equipment to permit isolation for maintenance and repair.

K. Balancing valves shall be installed in all domestic re-circulating systems and at all pumps, and where indicated on the drawings.

L. Unions shall be installed on all bypasses, at all connections to equipment, where shown on drawings or where required to facilitate removal of equipment whether shown or not.

M. Spring clamp plates (escutcheons) shall be provided where pipes are exposed in the building and run through walls, floors, or ceilings. Plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface.

N. If the size of any piping is not clearly evident in the drawings, the Contractor shall request instructions for the Engineer as to the proper sizing. Any changes resulting from the Contractor's failure to request clarification shall be at his expense. Where pipe size discrepancies or conflicts exist in the drawings, the larger pipe size shall govern.

O. Install all valves with stem upright or horizontal, not inverted.

P. Where pipe support members are welded to structural building framing, scrape, brush clean, weld and apply one coat of zinc rich primer.

Q. Provide clearance for installation of insulation and access to valves and fittings.

R. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

S. All water containing pipes shall be routed clear of combustion air dampers and louvers to prevent freezing condition when dampers are open.

T. Provide manual air vents at top of piping systems.

U. Where access doors are required, install piping so that valves can be grouped together to minimize the quantity of access doors.

V. Install manufactured U.L. listed firestop collars at all floor/wall penetrations for all Uponor and upon or pipe penetrations.

3.2. THERMOMETER AND PRESSURE GAGE INSTALLATION REQUIREMENTS.

A. Install thermometers and adjust vertical and tilted positions.

B. Install separable sockets in vertical position in piping tees where fixed thermometers are indicated.

1. Install with socket extending to one-third diameter of pipe.
2. Fill sockets with oil or graphite and secure caps.

C. Install pressure gages in piping tees with pressure-gage valve located on a pipe at most readable location.

D. Adjust faces of thermometer and gages to proper angle for best visibility.

E. Clean windows of thermometer and gauges and clean factory-finished surfaces. Replace cracked and broken window, and repair scratched and marred surfaces with manufacturer's touch up paint.

3.3. VALVE INSTALLATION REQUIREMENTS

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until 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 from fully open to fully closed positions. Examine guides and seats made accessible by such operation.

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. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

F. Examine grooved ends for form and cleanliness. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.

G. Do not attempt to repair defective valves; replace with new valves.

H. Install valves as indicated, according to manufacturer's written instructions.

I. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

J. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.

K. Locate valves for easy access and provide separate support where necessary.

L. Install valves in horizontal piping with stem at or above the center of the pipe.

M. Install valves in a position to allow full stem movement.

N. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.

3.4. WASTE AND VENT PIPING INSTALLATION REQUIREMENTS

A. Each pipe shall be laid true to line and grade and in such manner as to form a close concentric joint with the adjoining pipe and to prevent sudden offsets of the flow line. All pipe when laid shall rest on the full length of the barrel and bell holes shall be dug in trench bottoms to make joints. Pipe shall not be adjusted to grade by use of block or wedges. Where rock or old foundations are encountered, trenches shall be excavated 6-inches below grade and crusher run limestone shall be used as a bedding material to support barrel of pipe.

B. As the work progresses, the interior of the sewer shall be cleared of all dirt and superfluous materials of every description.

C. Trenches shall be kept free from water until the pipe jointing material has set and pipe shall not be laid when the conditions of the trench or the weather is unsuitable for such work. At all times, when work is not in progress, all open ends of pipe and fittings shall be securely closed to the satisfaction of the Engineer, so that no trench water, earth or other substance will enter the pipe or fittings.

D. Slip joints will be permitted only in trap seals or on the inlet side of the trap. Unions on the sewer side of the trap shall be ground faced, and shall not be concealed or enclosed. Install bell and spigot pipe with bell end upstream.

E. Threaded joints shall be American Standard taper screw threads with permacel joint compound applied to the male thread. Connections between threaded pipe and cast iron pipe shall have a ring or half coupling screwed on to form a spigot end on the threaded pipe.

F. Establish invert elevations, slopes for drainage to 1/8 inch per foot. Maintain gradients.

3.5. PIPE JOINTS INSTALLATION REQUIREMENTS

A. Welded Joints: Joints in piping 2-1/2-inches and larger shall be fusion welded. Welding shall be in accordance with recommendations of the American Welding Society. Welding fittings shall conform in physical and chemical properties to the latest revisions of the American Society for Testing Materials.

B. Qualify welding procedures, welders and operators in accordance with ASME B31.1, or ASME B31.9 as applicable, for shop and project site welding of piping work. Certify welding of piping work using Standard Procedure Specifications by, and welders tested under supervision of, National Certified Pipe Welding Bureau (NCPWB). Submit welders qualifications for approval.

C. Grooved Joints: Grooved joint shall be installed in accordance with the manufacturer’s written recommendations. Grooved ends shall be clean and free from indentations, projections, or roll marks. The gasket shall be molded and produced by the coupling manufacturer of an elastomer suitable for the intended service. The coupling manufacturer’s factory trained representative shall provide on-site training for the contractor’s field personnel in the use of grooving tools and installation of product. The representative shall periodically visit the job site to ensure best practices in grooved product installation are being followed. (A distributor’s representative is not considered qualified to conduct the training.)

D. Screwed Joints: All screwed joints shall be made with tapered threads properly cut. Screwed joints shall be made perfectly tight with a stiff mixture of graphite and oil, applied with a brush to the male threads on the fittings.

E. Soldered Joints and Copper Piping: Joints in copper piping shall conform to the following minimum standards.

1. The pipes shall be cut to a length making certain that the ends are square, using a fins hacksaw blade or tube cutter. The ends of all pipes shall be reamed and all burrs removed.
2. The outside end of the pipe and the cut end of the fitting shall be cleaned with steel wool, sand cloth, or steel wire brush. All dark spots shall be removed.
3. The flux shall be applied evenly and sparingly to the outside end of the pipe and the inside of the outer end of the fitting until all surfaces to be jointed are completely covered. The piping and fitting shall be slipped together and reworked several times to insure an even distribution of the flux.
4. The correct amount of solder per joint for each size pipe shall be used in accordance with the manufacturer's recommendations.
5. Solder joints shall be made by using a direct flame from a torch.
6. On pipe sizes larger than ¼-inch, the fittings and valves in the pipe shall be moved or tapped with a hammer when the solder starts to melt to insure an even distribution of the solder.
7. The excess solder shall be removed while it is still in the plastic state leaving a fillet around the cup of the fitting.
8. Solder joints shall be suitable for working pressure of 100 psig and for working temperature of not less than 250 degrees F. The type of solder and flux used will be submitted for approval. Type 95-5 shall be the minimum standard.
9. Lead and antimony-based solders shall not be used for potable water systems. Brazing and silver solders are acceptable.

F. Where copper piping joins steel piping, approved bronze adapters shall be used.

G. Prohibited Connections: No direct weld, soldered, or brazed connections, without unions or flanges, shall be made to valves, strainers, apparatus, or related equipment. Right and left couplings, long threads, or caulking of pipe threads or gasket joints will not be permitted.

H. When installing gas piping which is to be concealed (i.e., in walls), unions, tube fittings, running threads, right- and left-hand couplings, bushings, and swing joints made by combination of fittings shall not be used. All concealed piping within walls shall be welded.

1. Gas Piping
2. Final Gas Connections: Unless otherwise specified herein, final connections shall be made with rigid metallic pipe and fittings.
3. Pipe Joints:

a. Pipe joints shall be designed and installed to effectively sustain the longitudinal pull-out forces caused by contraction of the piping or superimposed loads.
b. Threaded Metallic Joints: Threaded joints in metallic pipe shall have tapered threads evenly cut and shall be made with UL approved graphite joint sealing compound for gas service. After cutting and before threading, pipe shall be reamed and burrs shall be removed. Caulking of threaded joints to stop or prevent leaks shall not be permitted.
c. Welded Metallic Joints: Beveling, alignment, heat treatment, and inspection of welds shall conform to ASME B31.2. Weld defects shall be removed and repairs made to the weld, or the weld joints shall be entirely removed and rewelded. After filler metal has been removed from its original package, it shall be protected or stores so that its characteristics or welding properties are not affected adversely. Electrodes that have been wetted or have lost any of their coating shall not be used.
d. Thermoplastic Joints: Jointing procedures shall conform to AGA 01. Solvent cement or heat of fusion joints shall not be made between different kinds of plastics.
e. Joining Thermoplastic to Metallic Piping: When compression-type mechanical joints are used, the gasket material in the fittings shall be compatible with the plastic piping and with the gas in the system. An internal tubular rigid stiffener shall be used in conjunction with the fitting, and the stiffener shall be flush with the end of the pipe or tubing and shall extend at least to the outside end of the compression fitting when installed. The stiffener shall be free of rough or sharp edges and shall not be a force fit in the plastic. A split tubular stiffener shall not be used.
f. Special Requirements; Drips, grading of the lines, freeze protection, and branch outlet locations shall be as shown and shall comply with NFPA 54 and/or NFPA-58.
g. Install containment conduits for gas piping below slabs, within building, in gastight conduits extending minimum of 4 inches (100mm) outside building, and vented to atmosphere. Terminate vents with turned-down, reducing-elbow fittings with corrosion-resistant insect screens in large end. Prepare and paint outside of conduits with coal-tar epoxy-polyamide paint according to SSPC-Paint 16.
h. Install gas meter per manufacturer’s requirements.
i. Install metal shut-off valves upstream and downstream of gas meter with full size normally closed bypass valve.
j. Install strainer on inlet of gas meter.

4. Install concrete filled, steel, schedule 40, painted pipe bollards around gas meter regulator and gas regulators serving generator.
5. Gas pressure regulators shall be installed and located per the manufacturer’s requirements for water heaters the gas regulators shall not be installed less than 3 feet nor more than 8 feet from the water heaters unless the manufacturer require otherwise. Vent all gas regulator vent pipes to the building exterior prior NFPA-54 and CSD-1 requirements.

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. Apply primer.
2. PVC Piping: Join according to ASTM D2855.

3.6. HANGERS AND SUPPORTS INSTALLATION REQUIREMENTS

A. General: All hangers shall be of an approved type arranged to maintain the required grading and pitching of lines to prevent vibration and to provide for expansion and contraction. Provide protection saddles between hangers and insulation on heating water insulated pipe. Saddles shall be Victaulic, Grinnells Figure 173/273, Sure-Joint, or approved equal. Provide approved spacers between saddles and pipe where flexible insulation is specified. Provide insulation protection shields for insulated piping without saddles. Shields shall be Carpenter Patterson, Grinnell Figure 167 or as approved equal.

B. Spacing: Regardless of spacing, hangers shall be provided at or near all changes in direction, both vertical and horizontal, for all piping. For cast iron soil pipe, one hanger shall be placed at each hub or bell.

C. Vertical Lines: Shall be supported at their bases, using either a suitable hanger placed in a horizontal line near the riser, or a base type fitting set on a pedestal, foundation or support. All vertical lines extending through more than one floor level shall be supported at each floor with a riser clamp. Riser clamp shall be Carpenter Patterson, Grinnell Co.'s Figure 261, or approved equal. All vertical drops to pump suction elbows shall be supported by floor posts.

D. Racks and Brackets: All horizontal piping on vertical walls shall be properly supported by suitable racks securely anchored into the wall construction. Where not practical to obtain ceiling anchorage, all piping near walls shall be supported by approved brackets securely anchored into the wall construction. Washer plates (Fib. 60, 60L) and other miscellaneous attachments, fasteners, etc., shall be Carpenter Patterson, Grinnell or as approved equal. All exterior hanger and bracket systems in their entirety shall be galvanized.

E. Pipe Hangers and supports shall be attached to the panel point at the top chord of bar joist or at a location approved by the structural engineer.

F. Select hangers and components for loads imposed. Secure rods with double nuts.

G. Support of horizontal piping shall allow for vertical adjustment after installation of piping.

H. Support overhead piping with clevis hangers.

I. Do not support all parallel piping from the same joist. Stagger all supports in accordance with the structural engineer's recommendations.

J. Refer to structural documents for appropriate connection/attachment materials to building.

3.7. AIR VENTING INSTALLATION REQUIREMENTS

A. The top of each plumbing piping system and other points as indicated or where necessary for the removal of air from the system or equipment, shall be vented using an approved type of manual air vent.

B. In addition to manual air vents at high points of system, each item of water heat transfer equipment shall be manually vented using an approved type manual air vent. All air vents shall be accessible.

3.8. DIRT POCKETS INSTALLATION REQUIREMENTS

A. Dirt pockets shall be installed at the base of all risers, upstream of gas regulators, and ahead of all gas equipment and as indicated on the drawings.

3.9. EXPANSION LOOPS AND SWING CONNECTION INSTALLATION REQUIREMENTS

A. Install expansion fittings according to manufacturer's written instructions.

B. Install expansion fittings in sizes matching pipe size in which they are installed.

C. Align expansion fittings to avoid end loading and torsional stress.

D. 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.

E. 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.

F. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

G. Connect risers and branch connections to plumbing equipment with at least four pipe fittings, including tee in riser.

H. Connect mains and branch connections to plumbing equipment with at least four pipe fittings, including tee in main.

I. Install expansion loops, guides, and anchors on all upon or domestic water piping as required per manufacturer’s instructions.

3.10. PIPING IDENTIFICATION REQUIREMENTS

A. All piping shall be identified with painted background marked with the name of the service with arrows to indicate flow direction. Color code and system identification shall comply with ANSI Standards and piping identification system shall comply with ASME A13.1-81., scheme for the identification of piping systems and ASHRAE Fundamentals Handbook, latest edition.

B. Markings shall be plain block letters, stenciled on pipes, and shall be located near each branch connection, near each valve, and at least every 10 feet on straight runs of pipe. Where pipes are adjacent to each other, markings shall be neatly lined up. All markings shall be located in such manner as to be easily legible from the floor. Pipe identification schedule shall be as follows:

OUTSIDE DIAMETER OF PIPE OR COVERING (INCHES)	LENGTH OF COLOR FIELD (INCHES)	SIZE OF LETTERS (INCHES)
½ to 1 ¼	8	½
1-½ to 2	8	¾
2 ½ to 6	12	1 ¼
8 to 10	24	2 ½
Over 10	32	3 ½

3.11. VALVE IDENTIFICATION REQUIREMENTS

A. All valves shall be tagged with a numbered tag.

B. The tags shall be made of 1-inch diameter brass tags fastened to the valve by means of brass chains. Numbers shall agree with valve numbers on diagrammatic herein before specified.

C. Provide a minimum of six (6) valve charts with valve numbers indicating valve type, size, manufacturer and service.

D. Additional valve charts shall be mounted behind glazed wooden frames and be hung in each mechanical equipment room including each air handling unit mechanical equipment room. Additional copies shall be provided in each copy of the O&M manuals.

3.12. CLEANING PIPING AND EQUIPMENT REQUIREMENTS

A. All water, plumbing piping, and pumped condensate systems shall be cleaned by filling with a solution of one (1) pound of trisodium phosphate to each 50 gallons of water and circulating this solution for a period of six (6) hours during which time the system shall reach operating temperature. The systems shall then be flushed with fresh water and refilled with fresh water purged of all air.

B. All water, plumbing, and pumped condensate piping system shall be flushed clean with fresh water. See Division 22 Sections, Plumbing Fixture and Plumbing Equipment for domestic potable water cleaning and sterilization.

3.13. BACKWATER VALVE INSTALLATION REQUIREMENTS

A. Install backwater valve with access door to allow service and cleaning of ball check valve.

B. Access door shall be adequate size to allow full clearance to backwater valves. Paint exterior of access door to match existing wall finish.

C. Backwater valve size shall be as indicated on floor plans.

3.14. PRESSURE SEAL FITTING INSTALLATION REQUIREMENTS

A. Viega, ProPress Pressure Seal bronze, Mueller Streamline, or approved equal or copper fittings: Sealing element shall be verified for the intended use. Tube ends shall be cut on a right angle (square) to the tube. Tube ends shall be reamed and chamfered, all grease oil or dirt shall be removed from the tube end with a clean rag. Visually examine the fitting sealing element to ensure there is no damage, and it is properly seated into the fitting. Utilizing a Viega Insertion Depth Inspection Gauge mark the tube wall, with a felt tip pen, at the appropriate location, or insert the tube fully into the fitting and mark the tube wall at the face of the fitting. Always examine the tube to ensure it is fully inserted into the fitting prior to pressing the joint. ProPress fittings shall be installed according to the most current edition of the Viega installation guidelines. Installers shall attend a Viega ProPress installation training class.

B. After ProPress, Mueller Streamline, or approved equal. Pressure seal fittings have been installed a “two step test” shall be followed. Pressurize the system with application appropriate test medium, water between 15 and 85 psi, or air/dry nitrogen between .5 and 45 psi. Check the pressure gauge for pressure loss. If the system does not hold pressure, walk the system and check for un-pressed fittings. Should you identify an un-pressed fitting ensure the tube is fully inserted into the fitting and properly marked, prior to pressing the joint. After appropriate repairs have been made, retest the system per local code, or specification requirements, not to exceed 600 psi with water or 200 psi when using air fitting.

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DIVISION 22 SECTION 22 07 01
PLUMBING INSULATION
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SECTION 22 07 01 - PLUMBING INSULATION

PART 1. GENERAL

1.1. REFERENCE

A. The Conditions of the Contract and other General Requirements apply to the work specified in this Section. All work under this Section shall be subject to the requirements of Division 22 Section, Common Work Results for Plumbing.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section

1.2. DESCRIPTION

A. All piping and equipment installed under this Contract shall be covered as specified.

1.3. SCOPE

A. The work covered by this specification consists of furnishing all labor, equipment, materials and accessories, and performing all operations required, for the correct fabrication and installation of thermal insulation applied to all piping, equipment, and systems, in accordance with applicable project specifications and drawings, subject to the terms and conditions of the contract.

1.4. STANDARDS

A. Thermal insulation materials shall meet the property requirements of one or more of the following specifications as applicable to the specific product or use:

1. American Society for Testing of Materials Specifications:

   a. ASTM C 547, “Standard Specification for Mineral Fiber Preformed Pipe Insulation”.
   b. ASTM C 533, “Standard Specification for Calcium Silicate Pipe & Block Insulation”.
   c. ASTM C 55, “Standard Specification for Mineral Fiber Blanket and Felt Insulation”.
   d. ASTM E 96, “Standard Test Methods for Water Vapor Transmission of Materials”.
   e. ASTM C 585, “Recommended Practice for Inner and Outer Diameters of Rigid Pipe Insulation for Nominal Sizes of Pipe and Tubing (NPS System)”.
   f. ASTM C 612, “Standard Specification for Mineral Fiber Block and Board Thermal Insulation”.
   g. ASTM C 1136, “Standard Specification for Barrier Material, Vapor, “Type 1 or 2 (Jacket only).
   h. ASHRAE 90.1 “Energy efficient design of new buildings except low-rise residential buildings”, latest edition.

B. Insulation materials, including all weather and vapor barrier materials, closures, hangers, supports, fitting covers, and other accessories, shall be furnished and installed in strict accordance with project drawings, plans, and specifications.

1.5. SYSTEM PERFORMANCE

A. Insulation materials furnished and installed hereunder should meet the minimum economic insulation thickness requirements of the North American Insulation Manufacturers' Association (NAIMA) (formerly known as TIMA), to ensure cost-effective energy conservation performance. Alternatively, materials should meet the minimum thickness requirements of National Voluntary Consensus Standard 90.1, (latest edition) and "Energy Efficient Design of New Buildings," of the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), latest edition. However, if other factors such as condensation control or personnel protection are to be considered, the selection of the thickness of insulation should satisfy the controlling factor. As minimum, all insulation thicknesses shall be as hereinafter specified.

B. Insulation materials furnished and installed hereunder shall meet the fire hazard requirements of any one of the following specifications:

1.	American Society for Testing of Materials	ASTM E 84
2.	Underwriters' Laboratories, Inc.	UL 723
3.	National Fire Protection Association	NFPA 255

C. Calcium silicate products shall include a visual identification system to permit positive field determination of their asbestos-free characteristics.

1.6. QUALITY ASSURANCE

A. Insulation materials and accessories furnished and installed hereunder shall, where required, be accompanied by manufacturers' current submittal or data sheets showing compliance with applicable specifications listed in Section 1.4 above.

B. Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in commercial insulation work.

1.7. DELIVERY AND STORAGE OF MATERIALS

A. All of the insulation materials and accessories covered by this specification shall be delivered to the job site and stored in a safe, dry place with appropriate labels and/or other product identification.

B. The Contractor shall use whatever means are necessary to protect the insulation materials and accessories before, during, and after installation. No insulation material shall be installed that has become damaged in any way. The Contractor shall also use all means necessary to protect work and materials installed by other trades.

C. If any insulation material has become wet because of transit or job site exposure to moisture or water, the Contractor shall not install such material, and shall remove it from the job site. An exception may be allowed in cases where the Contractor is able to demonstrate that wet insulation when fully dried out (either before installation, or afterward following exposure to system operating temperatures) will provide installed performance that is equivalent in all respects to new, completely dry insulation. In such cases, consult the insulation manufacturer in writing for technical assistance.

D. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements. Protect all insulation from water, construction traffic, dirt, chemical and mechanical damage.

1.8. ALTERNATES

A. Refer to Division 01 Section, Alternates for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. GENERAL

A. All materials to be insulated shall be thoroughly cleaned, after completion of successful tests, and shall be covered as specified below. Fiberglass insulation shall be Owens-Corning, Manville, Armstrong, or P.P.G, or as approved equal.

2.2. PIPE INSULATION MATERIALS

A. Unless otherwise noted, insulation shall be one piece or half sectional molded fibrous glass with “K” rating of .23 at 75 degrees F mean temperature, for service temperatures between -60 degrees F and +450 degrees F with all service poly-encapsulated jacket. Pipe insulation shall be fiberglass ASJmax SSL II with double closure system as manufactured by Owens Corning, Johns Manville, Knauf or approved equal.

B. Unless otherwise noted, pipe insulation jacket shall be factory-applied vinyl coated, embossed and reinforced vapor barrier laminate, with a perm rating of not more than 0.02 perms. All hot and cold, concealed, and exposed butt strips shall be of the same material as the jacket. Jacket and butt strips shall be sealed with field-applied Foster 85-20/85-50 or Childers CP-82 (5 gallon cans only) adhesive. Jacket and butt strips shall be off-white color and shall be equivalent to Owens-Corning Fiberglass 25-ASJ, Johns Manville, Knauf, or approved equal.

C. For fittings on all piping, valves, and flanges, apply fiberglass molded or segmented insulation equal in thickness to the adjoining insulation and securely fasten in place using wire. Cold piping: Apply a tack coat of vapor barrier coating and reinforcing mesh. After ½ hour, apply second coat of same vapor barrier coating, UL labeled, Type C, for cold water piping. Hot piping, Type H for hot water piping: Apply tack of breather mastic. Wrap fitting with fiberglass reinforcing cloth overlapping adjoining sections of pipe insulation by 2-inches. Apply a second coat of breather mastic over the reinforcing cloth, working it to a smooth finish. As an option to the above hot fittings, a polyvinyl chloride fitting cover may be supplied.

D. All pipe insulation, jackets, or facings, and adhesives used to adhere jacket or facing to the insulation, including fittings and butt strips, shall have non-combustible fire and smoke hazard system rating and label as tested by ASTM E-84, NFPA 225, and UL 73, not exceeding Flame Spread 25, Fuel Contributed 50, Smoke Developed 50. Accessories such as adhesives, mastic cements, tapes and cloth for fittings shall have the same ratings as listed above. All products or their shipping cartons shall bear the Underwriter's label indicating that flame and smoke ratings do not exceed the above criteria.

E. For piping having a vapor barrier insulation and for all insulated piping requiring supports, hangers and supports shall be installed outside the insulation. Wherever hangers and supports are installed outside the insulation, pipe insulation protecting shields shall be provided. Where insulation is a load bearing material, of sufficient strength to support the weight of the piping, pipe shields one-third the circumference of the insulation and of a length not less than three times the diameter of the insulation (maximum length 24-inches) shall be provided. Insulation of 7-1/4 pound or greater density will be considered as load bearing for pipe sizes up to and including 2-inches. Where insulation is not of sufficient strength to support the weight of the piping, a half section of high density fiberglass or foam inserts, shall be provided. Vapor barrier and finish shall be applied as required to match adjoining insulation. In addition, shields shall be furnished as specified above.

F. For piping located outside of the building, a corrugated aluminum weatherproof jacketing system shall be provided. This system shall be Micro-Lot ML as manufactured by Manville, Polyweld by Pabco Metals Corp., Childers, or as approved equal, and installed per the manufacturer's recommendations. Where outdoor piping is receiving electric heat tape, the insulation shall be oversized so that the heat tape is not compressed tightly to the pipe. Pipe jacketing shall be corrugated (3/16-inch) deep aluminum, .016-inch thickness of H-14 temper with aluminum strapping of .75-inch width and .020 inch thickness with moisture barrier. Aluminum jacketing elbows shall be smooth, .016-inch thickness and 1100 alloy. All jacketing shall have an integrally bonded moisture barrier over the entire surface in contact with the insulation. Longitudinal joints shall be applied so they will shed water and shall be sealed completely and shall be sealed completely with metal jacketing sealant. Sealant shall be Foster 95-44 or Childers CP-76. Circumferential joints shall be closed using preformed butt strips following manufacturer's recommendations for securement. Jacket seams shall be located on the bottom side of the horizontal piping.

G. On cold systems such as domestic cold water, rainleaders, vapor barrier performance is extremely important. All penetrations and seams of the ASJ and exposed ends of insulation must be sealed with vapor barrier coating. The ASJ must be protected with either a vapor barrier coating or a suitable vapor retarding outer jacket. Vapor seals at butt joints shall be applied at every fourth pipe section joint and at each fitting to provide isolation of water incursion. Vapor Barrier Coating: Foster 30-65; Childers CP-34 or Vimasco 749. Permeance shall be 0.03 perms or less at 45 mils dry at test by ASTM E96.

H. Fittings and valves shall be insulated with pre-formed fiberglass fittings, fabricated sections of Fiberglass pipe insulation, Fiberglass pipe and tank insulation, Fiberglass blanket insulation, or insulating cement. Thickness shall be equal to adjacent pipe insulation. Finish shall be with pre-formed PVC fitting covers or as otherwise specified on contract drawings. Where applicable, grooved joint PVC fitting valve and coupling covers shall be utilized. Grooved joint PVC covers shall be installed with matching pipe insulation jacketing material, vinyl tape, solvent weld adhesive and appropriate fasteners.

1. Flanges, couplings and valve bonnets shall be covered with an oversized pipe insulation section sized to provide the same insulation thickness as on the main pipe section. An oversized insulation section shall be used to form a collar between the two insulation sections with low density blanket insulation being used to fill gaps. Jacketing shall match that used on straight pipe sections. Rough cut ends

shall be coated with a suitable weather or vapor-resistant mastic as dictated by the system location and service. Finish valve installation with a Tyvac jacket with ends that secure to adjacent piping.

2. On hot systems where fittings are to be left exposed, insulation ends should be beveled away from bolts for easy access.
3. On cold systems, particular care must be given to vapor sealing the fitting cover or finish to the pipe insulation vapor barrier. All valve stems must be sealed with caulking which allows free movement of the stem but provides a seal against moisture incursion. All gauge and thermometer penetrations and extensions shall be correctly sealed and insulated to prevent surface condensation.

I. All piping shall be supported in such a manner that neither the insulation or the vapor/weather barrier is compromised by the hanger or the effects of the hanger. In all cases, hanger spacing must be such that the circumferential joint may be made outside the hanger. On cold systems, vapor barrier must be continuous, including material covered by the hanger saddle.

1. Piping systems 3-inches (7.5cm) in diameter or less, insulated with Fiberglass insulation, may be supported by placing saddles of the proper length and spacing, as designated in Owens-Corning Pub. 1-IN-12534, under the insulation. Hangers saddles shall be minimum 16 gauge with a saddle arc of 120 degrees minimum.
2. For hot or cold piping systems larger than 3-inches (7.5 cm) in diameter, operating at temperatures less than +200 degrees F (93 degrees C) and insulated with fiber glass, high density inserts such as foam with sufficient compressive strength shall be used to support the weight of the piping system. At temperatures exceeding +_200 degrees F (93 degrees C), Owens-Corning Pink or IIG, Calcium Silicate pipe insulation shall be used for high density inserts.
3. Owens-Corning Pink Calcium Silicate pipe insulation may be used to support the entire weight of the piping system provided the hanger saddle is designed so the maximum compressive load does not exceed 100 psi (7kg/cm).
4. Where pipe shoes and roller supports are required, insulation shall be inserted in the pipe shoe to minimize pipe heat loss. Where possible, the pipe shoe shall be sized to be flush with the outer pipe insulation diameter.
5. Thermal expansion and contraction of the piping and insulation system shall generally be taken care of by utilizing double layers of insulation and staggering both longitudinal and circumferential joints. Where long runs are encountered, expansion joints may be required where single layers of insulation are being used and should be so noted on the contract drawings.
6. On vertical runs, insulation support rings shall be used.

2.3. PIPING INSULATION THICKNESSES SCHEDULE

A. All piping shall be insulated with pipe insulation of the thicknesses indicted below:

PIPING INSULATION THICKNESS SCHEDULE SERVICES	THICKNESS
Above Grade Trap Priming Lines	½ -inch thickness
All Above Grade Floor Drain Piping Serving AHU	1-inch thickness

PIPING INSULATION THICKNESS SCHEDULE SERVICES	THICKNESS
Condensate Drains include Drain Sumps and Auxiliary Drain Pipes from Auxiliary Pans	
All Domestic Hot and Cold Water Piping, including Re-circulating Piping	1-inch thickness
All Drain Piping from Cooling Coils/Evaporators	½-inch thickness
All Horizontal Roof Drain Piping Including Sumps	1-inch thickness
Electric Water Cooler Drains, Kitchen Equipment Drains	1-inch thickness
Vertical and horizontal roof drain piping where the same handles A/C condensate.	1-inch thickness

2.4. EQUIPMENT INSULATION MATERIALS AND THICKNESSES

A. The following equipment shall be insulated with Fiberglass Rigid Board Insulation or Foam Plastic Insulation:

1. All piping within high-low mixing valve cabinets.
2. All Pump Volutes and Strainers.
3. Backflow Preventer Valve Bodies.
4. Domestic Booster Pump Suction and Discharge Headers.
5. Domestic Water Meters.
6. Expansion Tanks.
7. Make-up Water Valve Bodies.
8. Make-Up Water Meters.
9. Plumbing Pumps.

B. Insulation for cold surfaces shall be 1-1/2-inch thickness, 6 lb. density, 705 FRK with a "K" rating of .23 at 75 degrees F mean temperature. Insulation for hot surfaces except as otherwise noted shall be 1-1/2-inch thickness, 6 lb. density, 705 with a "K" rating of .23 at 75 degrees F mean temperature. Insulation shall be applied with staggered joints firmly butted and joined. The insulation shall be held in place by steel bands. Bands shall be 1-inch by 25 gauge galvanized steel spaced on not over 12-inch centers. All joints and voids shall be filled with Owens-Corning #110 cement, well troweled into openings. For 705 FRK insulation, all joints and voids shall be FRK taped and vapor sealed. There shall be applied over the insulation surface 1-inch galvanized wire netting laced together at all edges and wired to the steel bands with 16 gauge soft annealed wire. Over this shall be applied 2-inch thick layer of Owens-Corning #110 cement applied in two layers. Install metal corner beads at all corners and edges in order to provide a permanent installation. Onto the dry cement surface apply a brush coat of Foster Sealfas 30-36 or Childers CP-50AMV1 lagging adhesive at the rate of 60-70 square feet per gallon. Cleanouts, nameplates, and manholes shall not be insulated, and the insulation on surrounding surfaces shall be neatly beveled off at such openings.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes from aluminum at least 0.040 inch (1.0 mm) thick.
3. For below ambient services, install a vapor barrier coating at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

D. Mechanical fasteners shall be utilized to hold insulation to surface with bands as required to hold the curvature of the material.

E. Support rings shall be provided to support the top head insulation where required.

F. Outdoor installations require a weather barrier mastic for protection of the insulation jacketing.

G. Insulation types materials shall be suitable for temperatures encountered by each item of equipment.

H. Install removable insulation sections at all cleanouts, test ports, and items that must be periodically tested.

2.5. ACCESSORY MATERIALS

A. Accessory materials installed as part of insulation work under this section shall include, but not be limited to:

1. Closure Materials - Butt strips, bands, wires, staples, mastics, adhesives; pressure-sensitive tapes.
2. Field-applied jacketing materials - sheet metal, plastic, canvas, fiber glass cloth, insulating cement; PVC fitting covers, PVC jacketing.
3. Support Materials - Hanger straps, hanger rods, saddles.
4. Fasteners, weld pins/studs, speed clips, insulation washers.
5. Metal mesh or expanded metal lagging.

B. All accessory materials shall be installed in accordance with project drawings and specifications, manufacturer's instructions, and/or in conformance with the current edition of the Midwest Insulation Contractors Association (MICA) "Commercial & Industrial Insulation Standards."

2.6. FIELD-APPLIED JACKET

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, available products that may

be incorporated into the Work include, but are not limited to, the following:

a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto PVC Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer. VOC content not to exceed 250 g/L.
3. Color: High Gloss White
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

5. Factory-fabricated tank heads and tank side panels.

PART 3. EXECUTION

3.1. WORKMANSHIP

A. The Contractor shall take special care to prevent soiling equipment below or adjacent to areas being insulated. He shall be completely responsible for removing insulation cement splashes and smears and all surfaces that he mars or otherwise soils or defaces, and he will be totally responsible for restoring these damaged surfaces to their like-new condition when delivered to the site.

3.2. SITE INSPECTION

A. Before starting work under this section, carefully inspect the site and installed work of other trades and verify that such work is complete to the point where installation of materials and accessories under this section can begin.

B. Verify that all materials and accessories can be installed in accordance with project drawings and specifications and material manufacturers' recommendations.

C. Verify, by inspecting product labeling, submittal data, and/or certifications which may accompany the shipments, that all materials and accessories to be installed on the project comply with applicable specifications and standards and meet specified thermal and physical properties.

3.3. PREPARATION

A. Ensure that all pipe and equipment surfaces over which insulation is to be installed are clean and dry.

B. Ensure that insulation is clean, dry, and in good mechanical condition with all factory-applied vapor or weather barriers intact and undamaged. Wet, dirty, or damaged insulation shall not be acceptable for installation.

C. Ensure that pressure testing of piping systems has been completed prior to installing insulation.

3.4. INSTALLATION

A. Piping Systems

1. General:

a. Install all insulation materials and accessories in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended purpose.
b. Install insulation on piping subsequent to installation of heat tracing, painting, testing, and acceptance tests.
c. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other. Butt insulation joints firmly to ensure complete, tight fit over all piping surfaces.
d. Maintain the integrity of factory-applied vapor barrier jacketing on all pipe insulation, protecting it against puncture, tear or other damage. Seal all tears, punctures and other penetrations of the pipe insulation vapor barrier coating.
e. On exposed piping, locate insulation and cover seams in least visible location.

2. Fittings: Cover valves, fittings, unions, flanges, strainers, flexible connections, expansion joints, pump bodies, strainers, blowdowns, backflow preventers, autoflow valves and similar items in each piping system using one of the following:

a. Mitered sections of insulation equivalent in thickness and composition to that installed on straight pipe runs.
b. Insulation cement equal in thickness to the adjoining insulation.
c. PVC fitting covers insulated with material equal in thickness and composition to adjoining insulation.

3. Penetrations: Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise specified.
4. Joints:

a. Butt pipe insulation against hanger inserts. For hot pipes, apply 3-inch (7.5cm) wide vapor barrier tape or bank over butt joints. For cold piping, apply wet coat of vapor barrier lap cement on butt joints, and seal joints with 3-inch (7.5cm) wide vapor barrier tape or band.
b. All pipe insulation ends shall be tapered and sealed, regardless of service.

5. For heat traced piping, insulate fittings, joints, and valves with insulation of like material, thickness and finish as adjoining pipe. Size insulation large enough to enclose pipe and heat tracer. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

B. Equipment Insulation:

1. General:

a. Install insulation in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended purpose.
b. Install insulation on equipment after installation of heat tracing, painting, testing, and acceptance tests.
c. Install insulation materials with smooth, even surfaces. Rework poorly fitted joints. Do not use joint sealer or mastic as filler for joint gaps and excessive voids resulting from poor workmanship. Apply insulation using staggered joint method for both single and double layer installation, applying each layer of insulation separately.
d. Coat insulated surfaces where specified on contract drawings with layer of insulating cement, troweled in a workmanlike manner, leaving a smooth and continuous surface. Fill in seams, broken edges, and depressions. Cover over wire mesh and joints with cement sufficiently thick to remove surface irregularities.
e. Maintain the integrity of factory-applied vapor barrier jacketing on all insulation, protecting it against puncture, tears or other damage. Seal all tears, punctures and other penetrations of equipment insulation facing.
f. Where specification calls for field-applied all-service vapor barrier jacketing, it shall be neatly fitted and tightly secured. Lap seams 2-inches (5cm) (min.). Seal all joints with adhesive. Tape with 3-inches (7.5cm) matching pressure-sensitive tape or 3-inch (7.5cm) glass fabric and vapor barrier coating.
g. On exposed equipment, locate insulation and cover seams in least visible location.

2. Removable Insulation: Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance, such as vessel covers, fasteners, flanges, frames accessories, manholes, handholes, cleanouts ASME stamp, and manufacturer nameplates.
3. Areas Left Uninsulated: Items such as manholes, handholes, clean-outs, ASME stamp, and manufacturers' nameplates should be left uninsulated unless omitting insulation would cause a condensation problem. When such is the case, provide removable insulation and appropriate tagging to identify the presence of these items. Provide neatly beveled edges at interruptions of insulation.
4. Equipment Exposed to Weather: Protect outdoor insulation from weather by installation of weather barrier mastic protective finish or jacketing as recommended by the jacketing manufacturer.

3.5. FIELD QUALITY ASSURANCE

A. Upon completion of all insulation work covered by this specification, visually inspect the work and verify that it has been correctly installed. This may be done while work is in progress, to assure compliance with requirements herein to cover and protect insulation materials during installation.

3.6. PROTECTION

A. Replace damaged insulation which cannot be satisfactorily repaired, including insulation with vapor barrier damage and moisture-saturated insulation.

B. The insulation contractor shall advise the general and/or the mechanical contractor as to requirements for protection of the insulation work during the remainder of the construction period, to avoid damage and deterioration of the finished insulation work.

3.7. SAFETY PRECAUTIONS

A. Insulation contractor's employees shall be properly protected during installation of all insulation. Protection shall include proper attire when handling and applying insulation materials, and shall include (but not be limited to) disposable dust respirators, gloves, hard hats, and eye protection.

B. The insulation contractor shall conduct all job site operations in compliance with applicable provisions of the Occupational Safety and Health Act, as well as with all state and/or local safety and health codes and regulations that may apply to the work.

3.8. INSULATION COVERING

A. Unless otherwise noted, all exposed equipment insulation shall have a field applied PVC jacket cover neatly cut and pasted over equipment insulation. PVC shall be high gloss white and shall be 20 mils thick. Exposed areas include, but are not limited to, all mechanical equipment rooms/fan rooms, above architectural ceiling clouds, mezzanines, penthouses, boiler rooms, janitor’s closets, kitchens, electric rooms, and piping and ductwork exposed in an occupied space.

B. Unless otherwise noted, all exposed pipe insulation required to be insulated shall be jacketed with a PVC Jacketing with fitting covers. PVC jacket shall be color fade resistant, white high gloss, U.S.D.A. authorized as manufactured by Proto Corporation or approved equal. PVC jacketing shall be high impact, ultraviolet resistant PVC. Minimum thickness shall be 20 mils, roll stock ready for shop or field cutting and forming.

C. Where PVC jackets are indicated, install with 1 inch overlap at longitudinal seams and end joints, for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

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DIVISION 22 SECTION 22 40 00
PLUMBING FIXTURES

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SECTION 22 40 00 – PLUMBING FIXTURES

PART 1. GENERAL

1.1. GENERAL

A. For General Mechanical Requirements, see Division 22 Section, Common Work Results for Plumbing & Division 01, General Requirements.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specifications apply to this Section.

C. All exposed bolts, screws, etc., shall be vandal proof.

D. All plumbing materials, equipment and fixtures shall be new and of best grade, free of defects and complete with all required appurtenances and accessories.

E. Piping and insulation are specified under other sections.

F. Use "Sani-Sett" setting compound for fixtures.

G. Provide all materials, equipment and perform all labor required to install plumbing system complete as specified, as drawings indicated and as required by the following:

1. State of Delaware
2. International Plumbing Code
3. Town of Smyrna Code
4. All other authorities have jurisdiction.

H. Comply with the current lead-free laws per the requirements of the state in which the project is being constructed.

I. Provide stops for all plumbing fixtures and equipment. Stops are to be accessible.

J. Provide P traps on fixtures for which traps have not been included as part of furnished equipment. Trap size to equal size of fixture tailpiece.

K. All exposed metal parts of fixtures shall be chromium plated brass. Piping, fittings, valves, traps and accessories including escutcheons for piping shall be chromium plated where exposed in finished areas.

L. All faucets for the following list shall be listed for drinking-water or commercial applications by the National Sanitation Foundation (NSF) or Underwriters Laboratory (U.L.). All required faucets shall comply with NSF Standard 61 for both lead content and leaching rate. Submit documentation indicating compliance for all required faucets.

1. Residential kitchen sinks
2. Lavatories
3. Drinking fountains
4. Ice makers

M. Ensure products and installation of specified products are in conformance with recommendations and requirements of the following organizations:

5. National Sanitation Foundation (NSF).
6. American Society of Mechanical Engineers (ASME).
7. National Electrical Manufacturers' Association (NEMA).
8. Underwriters Laboratories (UL).

1.2. REFERENCES

A. ANSI/ASME A112.6.1 - Supports for Off-the-floor Plumbing Fixtures for Public Use

B. ASME A112.18.1 - Finished and Rough Brass Plumbing Fixture Fittings.

C. ANSI/ASME A112.19.1 - Enameled Cast Iron Plumbing Fixtures.

D. ANSI/ASMI A112.19.2 - Vitreous China Plumbing Fixtures.

E. ANSI/ASME A112.19.3 - Stainless Steel Plumbing Fixtures (Designed for Residential Use).

F. ANSI/ASME A112.19.4 - Porcelain Enameled Formed Steel Plumbing Fixtures.

G. ANSI/ASME A112.19.5 -Trim for Water-Closet Bowl, Tanks, and Urinals (Dimensional Standards).

H. ANSI/ARI 1010 - Drinking-Fountains and Self- Contained, Mechanically Refrigerated Drinking Water Coolers.

I. ANSI/NFPA 70 - National Electrical Code.

J. IBC - International Building Code

1.3. DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Division 01, Section General Requirements.

B. Accept fixtures on site in factory packaging. Inspect for damage.

C. Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.

1.4. FIELD MEASUREMENTS

A. Verify that field measurements are as indicated on shop drawings and per the manufacturer.

B. Confirm that millwork is constructed with adequate provisions for the installation of counter top lavatories and sinks.

1.5. EXTRA MATERIALS

A. Provide two sets of faucet washers and flush valve service kits to the Owner. Provide correspondence to Engineer that extra materials have been turned over to the Owner.

B. Provide 3 sets of electrical water cooler filters for each electric water cooler.

1.6. GRAB BAR COORDINATION

A. For handicapped plumbing fixtures coordinate location of flush valves with grab bars prior to installation.

1.7. ALTERNATES

A. Refer to Division 01 Section, Alternates for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. WALL-MOUNTED WATER CLOSETS

A. WC-1 Wall Hung, Exposed Manual Flush Valve

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Kohler Model K-4325 Kingston
   b. American Standard
   c. Crane
   d. Sloan
   e. Zurn

2. Bowl:

   a. Material: Vitreous china
   b. Type: Siphon Jet
   c. Style: Flushometer Valve
   d. Height: Standard
   e. Rim Contour: Elongated
   f. Spud Size; Location: NPS 1-1/2; Top

3. Flushometer Valve:

   a. Diaphragm Type: Sloan Model Royal #111, Delany, Zurn or approved equal.
   b. Chrome plated brass.
   c. ADA compliant non-hold open handle.
   d. 1-inch I.P.S. screwdriver back check angle stop.
   e. Spud coupling and flange.
   f. Free spinning vandal resistant stop cap.
   g. Adjustable tail piece.

h. High back pressure vacuum breaker flush connection.
i. Sweat solder adapter with cover tube and cast set screw wall flange.
j. Split Ring Wall Support: Sloan Model J-312-A.
k. Provide 3-year limited Manufacturer's warranty.

4. Toilet Seat: Kohler Model K-4670-C, American Standard 5901.100, solid plastic white seat with open front and check hinge.
5. Carrier: Zurn, Josam, or Watts cast iron watercloset Carrier with fittings as required. ANSI/ASME A112.6.1 adjustable cast iron frame integral drain hub and vent, adjustable speed, lugs for floor and wall attachment, threaded fixture studs with nuts and washers.

B. WC-1A Wall Hung, Exposed Manual Flush Valve, Handicapped

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Kohler Model K-4325 Kingston
b. American Standard
c. Crane
d. Sloan
e. Zurn

2. Bowl:

a.	Material:	Vitreous china
b.	Type:	Siphon Jet
c.	Style:	Flushometer Valve
d.	Height:	A.D.A. Compliant
e.	Rim Contour:	Elongated
f.	Spud Size; Location:	NPS 1-1/2; Top

3. Flushometer Valve:

a. Diaphragm Type: Sloan Model Royal #111, Delany, Zurn or approved equal.
b. Chrome plated brass.
c. ADA compliant non-hold open handle.
d. 1-inch I.P.S. screwdriver back check angle stop.
e. Spud coupling and flange.
f. Free spinning vandal resistant stop cap.
g. Adjustable tail piece.
h. High back pressure vacuum breaker flush connection.
i. Sweat solder adapter with cover tube and cast set screw wall flange.
j. Split Ring Wall Support: Sloan Model J-312-A.
k. Provide 3-year limited Manufacturer's warranty.

4. Seat: Kohler Model K-4670-C, American Standard 5901.100, solid plastic white seat with open front and check hinge.
5. Carrier: Zurn, Josam, or Watts cast iron watercloset Carrier with fittings as required. ANSI/ASME A112.6.1 adjustable cast iron frame integral drain hub and

vent, adjustable speed, lugs for floor and wall attachment, threaded fixture studs with nuts and washers.

2.2. WALL-HUNG URINALS

B. U-1A Wall-Hung, Exposed Manual Flush Valve, Handicapped

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Kohler Model K-4991-ET Bardon
   b. American Standard
   c. Sloan
   d. Zurn

2. Fixture:

   a. Material: Vitreous china
   b. Type: Washout
   c. Rim Height: A.D.A. Compliant
   d. Spud Size; Location: NPS 3/4; Top
   e. Outlet Size; Location: NPS 2; Back

3. Flushometer Valve:

   a. Diaphragm Type: Sloan Model Royal #186, Delany, Zurn or approved equal.
   b. Chrome plated.
   c. ADA compliant non-hold open handle.
   d. 3/4-inch I.P.S. screwdriver back check angle stop.
   e. Spud coupling and flange.
   f. Free spinning vandal resistant stop cap.
   g. Adjustable tail piece.
   h. High back pressure vacuum breaker flush connection.
   i. Sweat solder adapter with cover tube and cast set screw wall flange.
   j. Split Ring Wall Support: Sloan Model J-312-A.
   k. Provide 3-year limited Manufacturer's warranty.

4. Carrier: Zurn, Josam or Watts cast iron urinal carrier with fittings as required. ANSI/ASME A112.6.1A; cast iron and steel frame with tubular legs, legs for floor and wall attachment, threaded fixtures studs for fixture hanger, bearing studs.

2.3. WALL-MOUNTED LAVATORIES

A. LAV-4 Wall-Hung, Deck Mounted Metering Faucet

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Kohler Model K-2032 Greenwich
   b. American Standard Lucerne

c. Crane
d. Zurn

2. Fixture:

a.	Material:	Vitreous china
b.	Type:	Wall-Hung
c.	Rim Mounting Height:	Standard
d.	Nominal Size:	20-3/4"L x 18-1/4"W
e.	Faucet-Hole Punching:	Three Holes, 4-inch centers
f.	Faucet-Hole Location:	Top
g.	Color:	White
h.	Mounting Material:	Concealed Arm Carrier

3. Faucet:

a. Chicago Faucet 802-VE2805-665ABCP, Sloan, American Standard
b. Deck Mounted
c. Metering Push Handles
d. Low-Flow Outlet
e. Polished Chrome Finish
f. 4-inch Spout
g. Unit shall operate at less than 5 lbs. push at 80 psi water pressure.
h. Certification to comply with ADA shall be furnished

4. Strainer:

a. Chicago Faucet Model 327A, American Standard
b. 1-1/4-inch tailpiece
c. Non-removable brass strainer
d. Grid strainer waste
e. Chrome plated finished.

5. P-Trap:

a. Cast Brass 1-1/4-inch "P" trap

6. Stops:

a. Chicago Faucet Model l005-ABCP valve stops.
b. 3/8-inch loose key cap
c. Removable tee handle
d. Wall flange
e. Chrome plated finished.

7. Thermostatic Mixing Valves:

a. Provide and install below fixture.
b. See Part 2 "Thermostatic Mixing Valves".

8. Carrier:

a. Zurn, Josam, or Watts cast iron and steel carrier.
b. ANSI/ASME A112.6.1
c. Cast iron and steel frame with tubular legs.
d. Lugs for floor and wall attachment.
e. Concealed arm supports.
f. Bearing plate and studs.

B. LAV-4A Wall-Hung, Deck Mounted Metering Faucet, Handicapped

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Kohler Model K-2032 Greenwich
b. American Standard Lucerne
c. Crane
d. Zurn

2. Fixture:

a.	Material:	Vitreous china
b.	Type:	Wall-Hung
c.	Rim Mounting Height:	A.D.A. Compliant
d.	Nominal Size:	20-3/4"L x 18-1/4"W
e.	Faucet-Hole Punching:	Three Holes, 4-inch centers
f.	Faucet-Hole Location:	Top
g.	Color:	White
h.	Mounting Material:	Concealed Arm Carrier

3. Faucet:

a. Chicago Faucet 802-VE2805-665ABCP, Sloan, American Standard
b. Deck Mounted
c. Metering Push Handles
d. Low-Flow Outlet
e. Polished Chrome Finish
f. 4-inch Spout
g. Unit shall operate at less than 5 lbs. push at 80 psi water pressure.
h. Certification to comply with ADA shall be furnished

4. Strainer:

a. Chicago Faucet Model 327A, American Standard
b. 1-1/4-inch tailpiece
c. Non-removable brass strainer
d. Grid strainer waste
e. Chrome plated finished.

5. P-Trap:

a. Cast Brass 1-1/4-inch "P" trap

6. Stops:

   a. Chicago Faucet Model l005-ABCP valve stops.
   b. 3/8-inch loose key cap
   c. Removable tee handle
   d. Wall flange
   e. Chrome plated finished.

7. Thermostatic Mixing Valves:

   a. Provide and install below fixture.
   b. See Part 2 “Thermostatic Mixing Valves”.

8. Carrier:

   a. Zurn, Josam, or Watts cast iron and steel carrier.
   b. ANSI/ASME A112.6.1
   c. Cast iron and steel frame with tubular legs.
   d. Lugs for floor and wall attachment.
   e. Concealed arm supports.
   f. Bearing plate and studs.

9. Lavatory Protective Enclosure:

   a. Provide and install Truebro Model # 2018 lav shield lavatory enclosure on all lavatories with sensor operated faucets. Protective enclosure shall be ADA conforming, 20-inch x 18-inch wheel chair accessible. Unit shall have white finish, be constructed of high impact, stain resistant vinyl, and include seven (7) wall anchors.

2.4. MOP SINKS – SERVICE SINKS

A. JS-1 Mop Sink, Corner Unit

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Stern Williams Model Corlow-SBC

2. Fixture:

   a. Material: Terrazzo
   b. Type: Corner, Floor-mounted
   c. Size: 24”x24”
   d. Receptor composed of pearl grey marble chips and white Portland unit, ground smooth, grouted, and sealed to resist stains.
   e. Stainless steel cap of one piece 20 gauge, 302 stainless steel cast integral on threshold.
   f. Provide and install stainless steel BP splash Catcher panels on adjacent walls.

3. Faucet:

   a. Chicago Faucet 897-RCF, Speakman, American Standard
   b. Rough Chrome Finish
   c. Vacuum breaker spout
   d. Stop in arms
   e. 3/4-inch hose thread outlet.
   f. Pail Hook
   g. Wall Brace
   h. Stern-Williams T-35 hose, bracket and mop hanger.

B. JS-6 Service Sink

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Kohler Model K-6716
   b. American Standard
   c. Ceco

2. Fixture:

   a. Material: Enameled, Cast Iron
   b. Type: Trap Mounted
   c. Nominal Basin Size: 24-1/4”x20-1/4”x13”
   d. Rim Guard: Stainless Steel
   e. Wall Hanger Supports
   f. Provide and install stainless steel BP splash Catcher panels on adjacent walls.

3. Faucet:

   a. Chicago Faucet 305-VBRCF, American Standard
   b. Rough Chrome Finish
   c. Vacuum breaker spout
   d. Adjustable Stop supply arms
   e. 3/4-inch hose thread outlet.
   f. Pail Hook
   g. Vandal Proof Lever Handles

4. Strainer:

   a. Jomar Model SS-306 Snap-N-Loc basket strainer with brass locknut and tailnut.
   b. Deep cup body and basket shall be 300 series stainless steel

5. Trap:

   a. Kohler Model K-6673, American Standard
   b. 3-inch trap standard with cleanout

2.5. WATER COOLERS – FOUNTAINS

A. EWC-4 Electric Water Cooler, Dual Height, Surface Mounted, Handicapped, Bottle Filling Station

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Elkay Model LZSTL8WS
   b. Halsey Taylor
   c. Haws
   d. Oasis PG8EBFSL

2. Fixture:

   a. Barrier Free
   b. Dual Height with mounting frame
   c. 8 GPH at 90°F ambient
   d. 50°F outlet drinking water with 80°F inlet water
   e. Top shall be stainless steel
   f. Bubbler valve electronically controlled
   g. Bubbler shall be vandal resistant
   h. Activated by touch pads on sides and front for electronically timed period of flow.
   i. Cabinet shall be powder coated on heavy gauge steel, color to be selected by Architect.
   j. Supplied with plug-in, 3-wire grounding type service
   k. Operation on 120 VAC, Single Phase, 60Hz
   l. Lower Spout Outlet shall be mounted 36-inches maximum above floor.
   m. Upper Spout Outlet shall be mounted 42-inches maximum above floor.
   n. Water cooler and installation shall conform to all requirements of American Disabilities Act Guidelines and ANSI A117.l.

3. Bottle Filling Station:

   a. Electronic Sensor for No-Touch activation
   b. Automatic 20 second shut-off timer
   c. 1.1 GPM flow rate with laminar flow
   d. Water Sentry® Plus, 3,000 gallon capacity filter
   e. Certified to NSF/ANSI 61, UL 399 and CAN/CSA 22.2 No. 120.
   f. Provide replacement filter pack (3 filters per pack) and turn over to Owner.

4. Refrigerant shall be R-134a or equivalent environmentally friendly refrigerant.
5. Provide Carrier as manufactured by Elkay or approved equal.
6. Provide cane apron for water cooler (required where water coolers project more than 4 inches into the corridor).

2.6. COUNTER SINKS

A. S-1 Counter Sink – Single Bowl (Handicapped)

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Elkay Manufacturing Co. – Lustertone LRAD Series
    b. Just Manufacturing Co.

2. Fixture:

    a. Type: Single Bowl, Counter Mounted, Self-Rimming.
    b. Overall Dimensions (L x W x D) inches:

        19 x 18 x 5-1/2

    c. Material: 302 Stainless Steel, 18 gauge, fully coated underside.

3. Faucet:

    a. Standard: ASME A112.18/CSA B125.1
    b. General: Include hot and cold water indicators; coordinate faucet inlets with supplies and fixture hold punchings; coordinate outlet with spout and sink receptor.
    c. Model: Chicago Faucet Model 201-AGN8AE3-317ABCP
    d. Body Type: Centerset, 8" fixed centers
    e. Finish: Chrome Plated
    f. Handle(s): Model 317 Wrist Blade Handles, A.D.A. Compliant
    g. Mounting Type: Deck, concealed.
    h. Spout Type: Swivel gooseneck.
    i. Spout Outlet: E3 Aerator

4. Strainer: Jomar Model SS-306 Snap-N-Loc, or Just J-35 basket strainer and brass locknut and tailnut. Deep cup body and basket shall be 300 series stainless steel. Provide 1 ½-inch tailpiece.

5. P-Trap: Cast Brass 1 ½ -inch "P" trap.

6. Stops: Chicago Faucets Model 1005ABCP valve stops with riser supply, 3/8-inch loose key cap and removable tee handle, wall flange, chrome plated finish.

B. S-2 Counter Sink – Single Bowl (Handicapped)

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Elkay Manufacturing Co. – Lustertone LRAD Series
    b. Just Manufacturing Co.

2. Fixture:

    a. Type: Single Bowl, Counter Mounted, Self-Rimming.
    b. Overall Dimensions (L x W x D) inches:

31 x 22 x 5-1/2

c. Material: 302 Stainless Steel, 18 gauge, fully coated underside.

3. Faucet:

a. Standard: ASME A112.18/CSA B125.1
b. General: Include hot and cold water indicators; coordinate faucet inlets with supplies and fixture hold punchings; coordinate outlet with spout and sink receptor.
c. Model: Chicago Faucet Model 201-AGN8AE3-317ABCP
d. Body Type: Centerset, 8” fixed centers
e. Finish: Chrome Plated
f. Handle(s): Model 317 Wrist Blade Handles, A.D.A. Compliant
g. Mounting Type: Deck, concealed.
h. Spout Type: Swivel gooseneck.
i. Spout Outlet: E3 Aerator

4. Strainer: Jomar Model SS-306 Snap-N-Loc, or Just J-35 basket strainer and brass locknut and tailnut. Deep cup body and basket shall be 300 series stainless steel. Provide 1 ½-inch tailpiece.

5. P-Trap: Cast Brass 1 ½ -inch "P" trap.

6. Stops: Chicago Faucets Model 1005ABCP valve stops with riser supply, 3/8-inch loose key cap and removable tee handle, wall flange, chrome plated finish.

C. S-3 Art Room Counter Sink – Single Bowl (Handicapped)

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Elkay Manufacturing Co. – Lustertone LRAD Series
b. Just Manufacturing Co.

2. Fixture:

a. Type: Single Bowl, Counter Mounted, Self-Rimming.
b. Overall Dimensions (L x W x D) inches:

31 x 22 x 5-1/2

c. Material: 302 Stainless Steel, 18 gauge, fully coated underside.

3. Faucet:

a. Standard: ASME A112.18/CSA B125.1
b. General: Include hot and cold water indicators; coordinate faucet inlets with supplies and fixture hold punchings; coordinate outlet with spout and sink receptor.

c. Model: Chicago Faucet Model 201-AGN8AE3-317ABCP
d. Body Type: Centerset, 8” fixed centers
e. Finish: Chrome Plated
f. Handle(s): Model 317 Wrist Blade Handles, A.D.A. Compliant
g. Mounting Type: Deck, concealed.
h. Spout Type: Swivel gooseneck.
i. Spout Outlet: E3 Aerator

4. Strainer: Jomar Model SS-306 Snap-N-Loc, or Just J-35 basket strainer and brass locknut and tailnut. Deep cup body and basket shall be 300 series stainless steel. Provide 1 ½-inch tailpiece.

5. P-Trap: Cast Brass 1 ½ -inch "P" trap.

6. Stops: Chicago Faucets Model 1005ABCP valve stops with riser supply, 3/8-inch loose key cap and removable tee handle, wall flange, chrome plated finish.

7. Plaster Trap: For Art Room sinks provide Gleco or approved equal plaster trap in lieu of fixture “P”-trap. Unit shall by polypropylene with 19 oz. storage bottle, integral trap, unions and ball type drain valve. Furnish each sink with spare gasket and spare replacement bottle.

2.7. SHOWERS

A. SH-1 Shower (Handicapped):

1. Enclosure:

a. Enclosure and surrounding shower walls are provided under the Architectural Division.
b. Provide Rough-in and Final connection of cold, hot water, vent and waste.
c. Provide floor drain as specified on contract drawings.

2. Shower Valve:

a. Manufacturer: Powers Model P910H, Bradley WS-1X
b. Type: Manually Operated Shower Valve
c. Unit shall include showerhead, arm and flange.
d. Provide round face plate with red/blue indication inset.
e. Escutcheon shall be chrome plated stainless steel.
f. Provide 60-inch hose and in-line vacuum breaker with slide for use as a hand held shower to showerhead.
g. Shower and installation shall conform to all requirements of American Disabilities Act Guidelines and ANSI A117.1

3. Shower head:

a. Manufacturer: Bradley, Bricor, Speakman or approved equal.
b. Low-Flow Outlet.
c. 1.5 GPM at 30 psig.

d. Water conserving pressure compensating autodevice.
e. Polished Chrome Finish.
f. Provide and install Powers 141-600B three (3) port, in-line diverter valve to provide smooth transfer of water from hand held shower to showerhead.
g. Unit shall be ADA compliant and be finished with a stainless steel faceplate.

4. Shower Mixing Valve:

a. ASSE 1016 rated.
b. Combination pressure balancing/thermostatic mixing type.

2.8. CLOTHES WASHER - DRYER

A. LY-1 Residential Clothes Washer

1. Clothes washer provided by others. Provide rough-in, Outlet box(es) and final connections under this Division.

2. Sioux Chief: Model No. 696-R2313MF with 2-inch drain pipe, top supply, and shut-off valves with water hammer arresters. Provide flexible hose (3/4-inch) between Clothes washer and outlet box. Provide vacuum breakers on threaded outlets to prevent back siphonage. Unit shall be 16 gauge steel with white epoxy finish.

3. Inlet Hoses: Two, 60 inch long, ASTM D 3571, clothes washer inlet hoses with female hose-thread couplings.

4. Drain Hose: One, 48 inch long, ASTM D 3 3572 clothes washer drain hose with hooked end.

5. Auxiliary drain pans (for clothes washer): Plastic formed to slope from all directions to the drain connection.

2.9. OUTLET BOXES – WATER SUPPLY

A. OB-1 Refrigerator

1. Refrigerator provided in another Division of Specifications. Provide rough-in, Outlet box and final connections under this Division.

2. Sioux Chief: Model No. 696-RG1010MF with top supply and shut-off valve with water hammer arrester. Provide flexible hose (1/2-inch) between Refrigerator and outlet box. Provide vacuum breaker on threaded outlets to prevent back siphonage. Unit shall be 16-gauge steel with white epoxy finish.

3. Provide sufficient copper tubing to allow movement of refrigerator for cleaning.

2.10. HOSE BIBBS - HYDRANTS

A. HB-1 Hose Bibb

1. Chicago Faucet No. 952 or approved equal hose and faucet. Bronze or brass with integral mounting flange, replaceable hexagonal disc, hose threaded spout, polished chrome plated where exposed in finished areas, with hand wheel and removable key, integral vacuum breaker in conformance with ANSI/ASSE 1011.

2. Hose bibbs in finished areas shall be polished chrome finish.

3. Approved Manufacturers: Chicago Faucet, American Standard, Crane, T&S Brass, or Watts.

B. HYD-1 Wall Hydrant (Exterior)

1. Provide and install recessed anti-siphon wall hydrant, 3/4-inch non-freeze, key operated wall hydrant with hinged locking cover, polished bronze box and cover and bronze casing and integral vacuum breaker. Non-Freeze, exterior wall hydrants shall be Zurn Model Z-1320-XL, Josam, Wade, J.R. Smith, Mifab, Watts or approved equal.

2. Seat and disc shall be removable from front of the hydrant. Wall thickness; see architectural drawings. Wall hydrants shall conform to ANSI/ASSE 1019 with wall plate, lock shield and removable key.

C. HYD-2 Wall Hydrant (Interior)

1. Provide and install recessed wall hydrants where indicated on the contract drawings. Recessed wall hydrants shall be Zurn Model Z-1330, Josam, Ancon, Mifab, Watts or approved equal.

2. Units shall be encased Ecolotrol “anti-siphon" wall hydrant for interior wall installation. Unit shall be suitable for hot or cold water as indicated on Contract Drawings.

3. Each unit shall be complete with integral backflow preventer, all bronze interior parts, non-turning operating coupling with hemispherical neoprene plunger and 3/4-inch solder inlet.

4. Furnish each unit mounted in a stainless steel box and hinged cover with operating key lock and "water" stamped on cover.

5. Furnish each unit with the following accessories:

   a. 3/4 inch – 90 degrees inlet elbow with union nut
   b. Cylinder lock
   c. Key operator

D. HYD-6 Hydrant – Roof

1. Roof hydrant shall be exposed, non-freeze roof hydrant with Dura-coated cast iron head and lift handle with lock option, bronze interior parts, galvanized steel casing, and bronze valve housing with 1/8 inch IP drain port in housing. Provide Dura-coated cast iron support sleeve with wide anchoring flange and clamp collar.

2. Approved Manufacturers: Zurn or approved equal.

2.11. STORM DRAINS

A. General Requirements

1. Provide Josam 26200, Watts, or Zurn vertical expansion joint in each rain leader that does not have 90 degrees offset downstream of the roof drain. The expansion sleeve shall be bronze and shall conduct the rainwater beyond the packing. Install expansion joints in accessible locations for repacking.

B. SD-1 Storm Drain - Primary

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Zurn Z-100
   b. MIFAB R1200
   c. Watts

2. 15-inch diameter roof drain, dura coated cast iron body with combination membrane flashing clamp/gravel guard and low silhouette aluminum locking dome. Provide with support ring, adjustable top with wide roof flange, large sump with anchor flange, bottom outlet inside caulk connection and deck clamp.

C. SD-5 Storm Drain – Roof Condensate Drain

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Zurn Z-108
   b. MIFAB R1100-RS

1. 15” Diameter dura-coated cast iron body with combination membrane flashing clamp, deck receptor frame, internal bottom dome strainer and external 2-inch overflow dam.

2.12. FLOOR DRAINS

A. General Requirements

1. Provide Nikaloy strainers on all floor drains unless specified otherwise.
2. Provide flashing clamps on all drains penetrating waterproofing membrane.
3. Provide suitable flashing material and clamping collar for drains which are not set in place when slab is poured.
4. Provide backwater valves for all floor drains connecting directly to the storm water system. Depending on conditions of the particular installation, backwater valves may be an integral part of the drains or a separate device. Accessibility to valves must be maintained for maintenance. Provide an adequately sized extension sleeve up to floor or grade as required.

5. Backwater valves are normally closed, flapper type with bronze or brass seat and disc and stainless steel pin.
6. Provide traps for all floor drains connected to the sanitary system.
7. Provide E & S, Sioux Chief, or PPP primer valve (one valve per trap, per floor drain) on all remote floor drains. When installed on fixture in finished area, primer valve shall be concealed behind a Josam 58650, Watts, or Zurn access door. In Mechanical Rooms, mezzanines, penthouses, and all other locations indicated on the contract drawing, priming lines shall be connected to automatic trap primer.
8. In lieu of joints specified in piping section, neoprene gaskets may be used if designed for use with the drains and cleanouts employed and if approved by the local plumbing authority.
9. Where applicable, for floor drains utilized for washing machines, provide a stainless steel lint screen/strainer.
10. When floor drains collect condensate from a water heater neutralizer kit, the floor drains shall be provided with epoxy coating.
11. Approved Manufacturers: Josam, J.R. Smith, Zurn, Wade, Ancon, Mifab, Watts.

B. FD-1 Floor Drain – Round – Nickel Bronze Strainer

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Zurn ZN-415B
   b. Watts FD-100-A

2. Floor and shower drain, dura coated cast iron body with bottom outlet, combination invertible membrane clamp and adjustable collar with seepage slots and Type "B" polished nickel bronze strainer. Provide with ½ -inch trap primer connection.

2.13. FLOOR SINKS

A. FS-2 Floor Sink (12”x12”x6”)

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Zurn Z-1900
   b. Watts FS-730

2. Sani-Flor receptor, 12-inch x12-inch x 6-inch deep cast iron body and square, slotted grate with white acid resisting coated interior and top, complete with aluminum anti splash interior bottom dome strainer.

   a. Two (2) removable ½ grates with each unit.
   b. ½ -inch trap primer connection.
   c. Stainless steel mesh bucket screen.

B. FS-3 Floor Sink (12”x12”x8”)

1. Manufacturers: Subject to compliance with requirements, provide products by one

of the following:

a. Zurn Z-1901
b. Watts FS-740

2. Sani-Flor receptor, 12-inch x12-inch x 8-inch deep cast iron body and square, slotted grate with white acid resisting coated interior and top, complete with aluminum anti splash interior bottom dome strainer.

a. Two (2) removable ½ grates with each unit.
b. ½ -inch trap primer connection.
c. Stainless steel mesh bucket screen.

C. FS-5 Floor Sink (16”x16”x12”)

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Zurn Z-1926
b. Watts FS-850

2. Sani-Flor receptor, 16-inch x 16-inch x 12-inch deep cast iron body and square, slotted grate with white acid resisting coated interior and top, complete with aluminum anti splash interior bottom dome strainer.

a. Two (2) removable ½ grates with each unit.
b. ½ -inch trap primer connection.
c. Stainless steel mesh bucket screen.

2.14. THERMOSTATIC MIXING VALVES (INDIVIDUAL FIXTURE TYPE)

A. Furnish and install thermostatic mixing valves at lavatories, and kitchen hand sinks.

B. Thermostatic mixing valves shall be Bradley S59-4000A, Watts, Moen, Leonard EcoMix, Acorn, or approved equal for installation under lavatories. Provide in-line check valves, lead free body, escutcheon plates, inlet filters, and insulation as required. Thermostatic mixing valves shall be adjusted to deliver 105 degrees Fahrenheit hot water when supplied with 140 degrees Fahrenheit delivering hot water. Furnish with adjusting cap with locking feature.

C. The thermostatic mixing valves shall be listed for use at the scheduled flow rate of the equipment served.

D. The thermostatic mixing valves shall be ASSE standard 1070 listed.

2.15. PLUMBING FIXTURE SUPPORTS

A. Wall mounted urinal supports, Josam 17810 plate type with cast iron headers, box steel stanchions, block type cast iron feet with bearing plate.

B. Support for wall mounted urinals, lavatories, sinks, drinking fountains, etc.:

C. Where fixtures are supported from concrete or cinder block walls, install No.10 USSG Steel plate on the opposite side of the wall and bolt hangers or supports through plate. Where opposite side of wall is exposed to view, place bolts in core of blocks and fill core with cement.

D. Where lavatories with wall hangers have been specified and fixtures are supported from metal stud frame partitions, fixture brackets or mounting lugs shall be through bolted to steel channel crosspieces not less than 1-1/2-inch wide anchored to studs. Bolt heads shall be welded to channel web.

E. Concealed arm type lavatory supports, Josam 17100 with cast iron headers, box steel stanchions, block type cast iron feet and header; and chrome plated cast brass threaded escutcheons for slab type lavatories.

F. Flush mounted drinking water cooler supports, Josam 17550 plate type, box steel stanchions, block type cast iron feet.

G. Water closet chair carriers, Josam 12000 Series for horizontal and vertical installations.

2.16. HANDICAPPED LAVATORY/SINK INSULATION

A. All handicapped lavatories and sinks shall be provided with under counter pipe and trim insulation.

B. Insulation shall be fully molded "P" trap and angle valve insulated Hand-I-Lav Guard, Truebro, Pro-Extreme Model #101, 102, and 105 to suit.

C. Insulation to meet ADA #4 19.4, ANSI A117.1, ASTM C1822, Type III and International Plumbing Code.

D. Self-extinguishing ASTM D635 burn characteristics, thermal conductivity ASTM C177 K-Value ' 1.17.

E. Insulation thickness to be minimum 2 inch.

F. Where lav. Guards are provided insulation may be omitted.

2.17. FIXTURE STOPS/SUPPLIES

A. For all lavatories/sinks stops and supplies shall be Chicago Faucets No. 1017-CR43829, Angle Stop Fitting with Supply Tube and Loose Key, Chrome plated solid brass construction. 2-1/4” Metal tee handles with tapered square. Slow compression check cartridge that shall open and close 360º for fine adjustment, valves shall close with water pressure, furnish with square tapered stem. ½” NPT female thread inlet 3/8” O.D. female compression outlet. Slip wall flange. 3/8” O.D. x 12” bullnose flexible supply riser. ECAST construction with less than 0.25% lead content by weighted average. This product shall be tested and certified to industry standards: ASME A112.18.1/CSA B125.1, Certified to NSF/ANSI 61, Section 9 by CSA, California Health and Safety Code 116875 (AB1953-2006), Vermont Bill S. 152, and NSF/ANSI 372 Low Lead Content.

PART 3. EXECUTION

3.1. GENERAL INSTALLATION REQUIREMENTS

A. Install all equipment in accordance with manufacturer's instructions.

B. Setting heights of lavatories, drinking fountains, etc., shall be as directed prior to installation and shall be coordinated with Architectural Contract Documents.

C. Install floor mounted fixtures only after finished floor has been installed.

D. Provide rubber concussion washers between vitreous china fixtures and supporting brackets.

E. Protect chromium plated trim from corrosive solutions used to clean tile work.

F. Provide white, silicone caulking where fixtures come in contact with walls and floors. Sealant shall be mildew resistant type in accordance with ANSI A-136.1.

G. Install components plumb and level.

H. Unless otherwise noted, drains are to be installed at the low point of floors. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

I. Install floor drains in low points so the top of grates are at or below the finished floor level.

J. Drains not functioning properly shall be removed and re-installed properly at the expense of the contractor.

K. Coordinate cutting and forming of roof and floor construction to receive drains to required invert elevations.

L. Install and secure fixtures in place with wall supports, wall carriers and bolts.

M. Solidly attach water closets to floor with lug screws. Lead flashing is not intended to hold fixture in place.

N. Install flush valve handles on the open side of all ADA waterclosets in accordance with ANSI requirements.

O. Fixtures shall be vitreous china unless otherwise noted. Cast iron fixtures shall have acid resisting enamel finish unless noted otherwise, color shall be white.

P. Flush valves shall be self-closing, non-hold open type with vacuum breaker and perform satisfactorily when subject to inlet water pressure varying from 15 to 75 psi. Flush valves shall be as specified, Sloan, Delaney, Zurn, Toto, or approved equal.

Q. Provide flexible risers and loose key stops for all lavatories and sinks. Provide 17 ga. chrome plated brass tail piece and trap with cleanout for all lavatories and sinks.

R. Fittings for fixtures supplied by others, such as kitchen equipment are provided under another division of these specifications. Connections of these fixtures to the plumbing system are provided under this section.

S. Coordinate with plumbing piping and related fuel piping, gas venting and electrical work to achieve a complete operating system.

T. All plumbing vents within a 10'-0" radius of exhaust vents shall be extended to a height of 3'-0" above exhaust vent crown.

U. All plumbing vents within a 10'-0" radius of any rooftop unit or intake louver shall be extended to a height of 3'-0" above fresh air intake.

V. Slopes and invert elevations of all interior piping shall be established before any piping is installed in order that proper slopes will be maintained. All piping shall be located and determined where to be run to avoid conflict with other trades.

W. Unless otherwise noted, all plumbing piping shall be routed as high as possible between bottom of roof joists and above ceiling to allow proper installation of ductwork, fire protection piping, conduits, etc.

X. Coordinate with Architectural Drawings before roughing in plumbing.

Y. All openings in ceilings and plenum walls for plumbing shall be sealed air tight and protected with fire stop.

Z. See site plan for extent of all piping leaving and entering building.

AA. See domestic water riser diagrams for location of valves, shock absorbers, etc.

BB. Make proper hot water, cold water, hot water recirculating, waste, and vent connections to all fixtures and equipment even though all branch main, elbows and connections are not shown.

CC. Unless otherwise noted, sanitary waste piping shown is below floor and all other piping is overhead, above ceiling. Domestic hot, cold and recirculating water piping shall be installed between ceiling and attic insulation.

DD. Unless otherwise noted, horizontal sanitary piping shall be pitched 1 percent.

EE. Unless otherwise noted, all domestic water piping and fire protection piping shall be installed on heated side of ceiling insulation.

FF. All piping and installation shall comply with all local and national plumbing codes. Test piping as required by plumbing code and authority having jurisdiction.

GG. For sizes of all domestic water piping see plumbing fixture schedule and domestic water riser diagrams.

HH. For sizes of all sanitary and vent piping see plumbing fixture schedule and sanitary/vent riser diagrams.

3.2. PLUMBING SPECIALTY INSTALLATION REQUIREMENTS

A. General: Install plumbing specialty components, connections, and devices according to manufacturer's written instructions.

B. Fasten recessed, wall-mounting plumbing specialties to reinforcement built into walls.

C. Secure supplies to supports or substrate.

D. Install individual stop valve in each water supply to plumbing specialties. Use ball, gate, or globe valve if specific valve as appropriate is not indicated.

E. Install water-supply stop valves in accessible locations.

F. 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.

G. Include wood-blocking reinforcement for recessed and wall-mounting plumbing specialties.

3.3. FITTINGS FOR FIXTURES SUPPLIED BY OTHERS

A. Fixtures such as kitchen equipment may be provided under other divisions of the specifications and are complete with strainer and tailpiece. Fittings, accessories and connection of these fixtures to the plumbing system are provided under this section.

B. Rough-in and final connection includes but is not limited to all domestic water, waste, vent, and gas systems. Furnish stops, strainers, vacuum breakers, and under counter insulation where not furnished under another Division of these specifications.

3.4. TESTING

A. After plumbing fixtures are connected, all piping and fixtures shall be tested for operation and a smoke or peppermint test shall be made on all soil, waste and vent piping.

B. After the building has been occupied and the various equipment is in actual use, the Contractor shall make an operating test of all equipment at a time directed by the Engineer to determine that all contract requirements are met.

3.5. CLEANING AND STERILIZATION

A. After final testing for leaks, all potable water lines shall be thoroughly flushed, by plumbing contractor, to remove foreign material. Before placing the systems in service, sterilize the new water lines in accordance with local health department codes and at a minimum according to the following procedure:

B. Through a 3/4-inch hose connection in each branch main and building main, pump in sufficient sodium hypochlorite to produce a free available chlorine residual of not less than 200 ppm. Plumbing Contractor shall provide plumbing connections and power for pumping chlorine into system.

C. Proceed upstream from the point of chlorine application opening all faucets and taps until chlorine is detected. Close faucets and taps when chlorine is evident.

D. When chlorinated water has been brought to every faucet and tap with a minimum concentration of 200 ppm chlorine, retain this water in the system for at least three (3) hours.

E. CAUTION: Over-concentration of chlorine and more than three (3) hours of retention may result in damage to piping system. It is not necessary to retain chlorine in any system for twenty-four hours to achieve sterilization. AWWA states that 200 ppm chlorine for three hours is sufficient.

F. At the end of the retention period, no less than 100 ppm of chlorine shall be present at the extreme end of the system.

G. Proceed to open all faucets and taps and thoroughly flush all new lines until the chlorine residual in the water is less than 1.0 ppm.

H. Obtain representative water sample from the system for analysis by an independent and recognized bacteriological laboratory.

I. If the sample tested for coliform organisms is negative, a letter and laboratory report shall be submitted by the service organization to the Contractor, certifying successful completion of the sterilization. Additionally, this report shall be forwarded to the Owner as well as be included in the O&M Manual.

J. If any samples tested indicate the presence of coliform organisms, the entire sterilization procedure shall be repeated.

K. Take precautions to avoid use of plumbing fixtures and domestic water systems during sterilization period. Place signs on all plumbing fixtures and outlets during sterilization period.

3.6. EXAMINATION

A. Verify that walls and floor finishes are prepared and ready for installation of fixtures.

B. Verify that electric power is available and of the correct characteristics.

3.7. PREPARATION

A. Review the Kitchen Equipment Consultant's equipment cut sheets. Confirm rough-in location and size of fixtures and openings prior to commencing work.

B. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

3.8. INTERFACE WITH OTHER PRODUCTS

A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.

3.9. ADJUSTING

A. Adjust stops, valves, for intended water flow rate to fixtures without splashing, noise, or overflow.

3.10. CLEANING

A. At completion, clean plumbing fixtures and equipment. Polish all chrome plated faucets, accessories, equipment, and piping.

B. All electric water cooler coils shall be cleaned of all construction dust and debris prior to building occupation by Owner.

3.11. FIXTURE HEIGHTS

A. Install fixtures to heights above finished floor as required by local Plumbing Code, Americans with Disabilities Act (A.D.A.), Authority Having Jurisdiction, and Architectural Contract Drawings. In the absence of a local code requirements, install fixtures to heights above finished floor as follows.

B. Water Closet

a. Standard 15 inches to top of bowl rim.
b. Handicapped 18 inches to top of seat.

C. Urinal

a. Handicapped 17 inches to top of bowl rim.

D. Lavatory

a. Standard 31 inches to top of basin rim.
b. Handicapped 34 inches to top of basin rim.

E. Drinking Fountain

a. Handicapped 34 inches to top of basin rim.

F. Water Closet Flush Valves

a. Standard 11 inches min above bowl rim.
b. Recessed 10 inches min. above bowl rim.

G. Shower Heads

a. Adult male 80 inches to bottom of head.
b. Adult female 76 inches to bottom of head.
c. Handicapped (unisex) with handheld 76 inches to top of head arm.
d. Handicapped (unisex) without handheld 48 inches to top of head arm.

H. Residential Clothes Washer

a. Guy Gray box 42 inches above finished floor.

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PLUMBING EQUIPMENT
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SECTION 22 40 05 - PLUMBING EQUIPMENT

PART 1. GENERAL

1.1. GENERAL

A. For General Mechanical Requirements, see Division 22 Section, Common Work Results for Plumbing & Division 01, General Requirements.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specifications apply to this Section.

C. All exposed bolts, screws, etc., shall be vandal proof.

D. All plumbing materials and equipment shall be new and of best grade, free of defects and complete with all required appurtenances and accessories.

E. Piping and insulation are specified under other sections.

F. Provide all materials, equipment and perform all labor required to install plumbing system complete as specified, as drawings indicated and as required by the State of Delaware, National Standard Plumbing Code , International Plumbing Code, Town of Smyrna Code, the local code, and all other authorities have jurisdiction.

G. Provide stops for all plumbing equipment. Stops are to be accessible.

H. Provide pumps with manufacturer's name, model number, and rating/capacity identified.

I. Ensure products and installation of specified products are in conformance with recommendations and requirements of the following organizations:

1. American Gas Association (AGA).
2. National Sanitation Foundation (NSF).
3. American Society of Mechanical Engineers (ASME).
4. National Board of Boiler and Pressure Vessel Inspectors (NBBPVI).
5. National Electrical Manufacturers' Association (NEMA).
6. Underwriters Laboratories (UL).

J. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitations, are non-overloading in parallel or individual operation, operate within 25 percent of midpoint of published maximum efficiency curve.

1.2. REFERENCES

A. ANSI/ASSE 1011 - Hose Connection Vacuum Breakers.

B. ANSI/ASSE 1013 - Backflow Preventers, Reduced Pressure Principle.

C. ANSI/ASE 1019 - Wall Hydrants, Frost Proof Automatic Draining Anti-Backflow Types.

D. ANSI A112.21.1 - Floor Drains.

E. ANSI A112.21.2 - Roof Drains.

F. ANSI A112.26.1 - Water Hammer Arrestors.

G. AWWA C506 - Backflow Prevention Devices - Reduced Pressure Principle and Double Check Valve Types.

H. PDI WH-201 Water Hammer Arresters.

I. ANSI/ASHRAE 90A - Energy Conservation in New Building Design.

J. ASME Section VIIID - Pressure Vessels; Boiler and Pressure Vessel Codes.

K. ANSI/NFPA 54 - National Fuel Gas Code.

L. ANSI/NFPA 70 - National Electrical Code.

1.3. DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of General Requirements.

B. Accept equipment on site in factory packaging. Inspect for damage.

C. Protect installed equipment from damage by securing areas and by leaving factory packaging in place to protect equipment and prevent use.

1.4. FIELD MEASUREMENTS

A. Verify that field measurements are as indicated on shop drawings and per the manufacturer.

1.5. ALTERNATES

A. Refer to Division 01 Section, Alternates for description of work under this section affected by alternates.

1.6. EXTRA MATERIALS

A. Provide one set of pump seals for each type of model of pump provided on this project.

B. For all condensing water heaters, provide spare set of lime chips for all condensate neutralizers.

PART 2. PRODUCTS

2.1. CLEANOUTS

A. Provide cleanouts in sanitary and storm drainage systems at ends of runs, at changes in direction, near the base of stacks, every 50 feet in horizontal runs, of 4-inch diameter or less, every 100 feet in horizontal runs over 4-inches, and where indicated.

B. Cleanouts shall be full size of pipe up to 4-inches and shall be 4-inches for larger sizes.

Where installed in finished floors inserts shall match adjacent floor construction.

C. Materials and Approved Manufacturers: Josam, J.R. Smith, Zurn, Wade or Ancon, Mifab, Watts, equal to Josam numbers given below:

1.	Concealed Piping	C.I. Pipe
2.	Unfinished Areas	
3.	Floors	57000-Z-CI
4.	Walls	58600-PLG
5.	Finished Areas Floors	
6.	Terrazzo	56040-13
7.	Composition Tile	57000-X-12
8.	Ceramic Tile	57000-X
9.	Carpet	56070-14
10.	Carpet insert to match adjacent carpet in type, color and grade.	
11.	Finished Areas Walls	
12.	Plaster/Dry Wall	58640-COT
13.	Tile/CMU	58600-COT

2.2. SHOCK ABSORBERS

A. Provide shock absorbers equal to Josam Shokstops at all fast closing valves, at the top of all cold water risers, at each flush valve or battery of flush valves, and where indicated. Sizes and locations shall be in accordance with PDI Standard WH 201.

B. Shock absorbers shall conform to ANSI A112.26.1, precharged suitable for operation in temperature range -100 to 300 degrees F and maximum 250 psig working pressure.

C. Approved Manufacturers: Josam, Wade, Zurn, J.R. Smith, Sioux Chief, Watts, or approved equal.

2.3. VACUUM BREAKERS

A. Provide vacuum breakers on water connections to fixtures and equipment where minimum air gaps required by Plumbing Code are not possible and on hose bibbs and other outlets to which hoses can be attached.

B. Vacuum breakers not subject to back pressure, Watts No. 288A; vacuum breakers subject to back pressure, Watts Series 9D or for hose threads, Watts Series 8A.

C. Provide atmosphere vacuum breakers at all water connections to garbage disposers, hose spray units as required by Plumbing Code.

D. Hose connection backflow preventers shall be ASSE 1052, suitable for at least 5 gpm flow and applications with up to 10 foot head back pressure. Include two (2) check valves, intermediate atmospheric vent, and non-removable, ASME B1.20.7 garden-hose thread on outlet.

E. Hose connection vacuum breakers shall be 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. Approved manufacturers: Watts, Beeco, B&K Industries, Zurn, Sparco, Conbraco or approved equal.

2.4. VACUUM RELIEF VALVES

A. Provide vacuum relief valves on cold water supply to water heaters, where indicated on the contract drawings, or where required by the authority having jurisdiction.

B. Vacuum relief valves shall be Watts Regulator Co. Series 36A, Josam, or approved equal.

2.5. DOMESTIC WATER CARTRIDGE TYPE RE-CIRCULATING PUMPS

A. Provide and install domestic water re-circulating pumps of the size, capacity and electrical characteristics as indicated on the contract drawings. Pumps shall be in-line cartridge circulators as manufactured by Grundfos, Wilo, TACO, Bell and Gossett, Thrush, Armstrong, Patterson, or approved equal. Units shall be U.L. listed.

B. Pumps shall be non-overloading throughout the range of the curves. Pumps shall have center line discharge for positive venting, flanged bodies, and same size suction and discharge.

C. Motors shall be permanent split capacitor with built-in overload protection. Impellers shall be non-metallic. Casings shall be bronze construction. Shafts shall be ceramic with carbon bearings. Units shall be rate for 125psi maximum pressure and 220 degrees F maximum temperature.

D. All circulators utilized for domestic water service shall be all bronze construction. Shaft orientation and junction box orientation shall be installed per manufacturer's recommendations.

2.6. BACKWATER VALVES

A. Backwater valves shall be provided at all connections of floor drains or area drains to stormwater piping systems and where indicated on contract drawings.

B. Backwater valves shall be ANSI A112.21.2, coated cast iron body and cover, brass valve, access cover, extension sleeve and cover.

C. Backwater valves shall be equal to Josam 67360-15.

D. Extend access cover to finished floor and terminate in cleanout.

E. Approved Manufacturers: Josam, Zurn, Wade, Smith, Ancon or approved equal.

2.7. GAS FIRED DOMESTIC WATER HEATERS

A. Water Heater(s) shall be model BTH as manufactured by A. O. Smith, Lochinvar, State, Bradford White, Bock, PVI Conquest or approved equal. Water heater(s) shall be of the seamless glass lined steel tank construction in which the glass coating is applied to the water side surfaces of the tank after the tank has been assembled and welded. The condensing flue coil shall be coated on the flue gas side with A. O. Smith's proprietary or equal acid resistant glass lining designed for use in condensing heaters.

B. The heater shall be suitable for sealed combustion direct venting using PVC air intake pipe and PVC exhaust pipe for a total distance of (50') equivalent feet of vent and 50' equivalent feet of intake. The heater shall be factory assembled and tested. The power burner shall be of a design that requires no special calibrations or start up. The heater(s) shall be approved for 0-inch clearances to combustibles.

C. The control shall be an integrated solid state temperature and ignition control device with integral diagnostics, LED fault display capability and a digital display of temperature settings.

D. The tanks shall be foam insulated and equipped with a ASME rated temperature pressure relief valve. The water heater shall be UL listed and exceed the minimum efficiency requirements of ASHRAE/IES 90.1b-1992.

E. The heater shall be listed by SCAQMD Rule 1146.2 Low NOx. Water Heater shall comply with Delaware Pressure Vessel Code and ASME CSD-1.

F. Provide unit with brass drain valve and install on 4-inch high housekeeping pad as detailed on the contract drawings.

G. The water heater shall be tested at start-up by a qualified representative of the manufacturer. Provide a check list outlining start-up procedures to Engineer for review. A start-up report as provided by the manufacturer shall be completed and submitted before final acceptance of the domestic hot water heater system. Include copy of start-up report in O&M Manuals.

H. Conduct flue gas analysis on unit as required by water heater manufacturer.

I. Where multiple units are indicated furnish manifold kits to balance water flow through each heater.

J. Furnish units with electronic temperature control with LED readout.

K. Accessories: Air proving switch, housekeeping pad, low water cut-off, condensate neutralization kit, temperature and pressure relief valve. The temperature and pressure relief valve must be visible and accessible not hidden behind jacket.

L. Warranty: Total unit warranty of five (5) years.

M. A properly sized gas pressure regulator to be provided by the manufacturer and installed by the contractor.

2.8. BACKFLOW PREVENTER (REDUCED PRESSURE PRINCIPAL TYPE)

A. Furnish and install reduced pressure principal backflow preventers at all cold water make-up connections to HVAC water systems and where indicated on contract drawings.

B. Backflow preventers shall be of bronze body construction, inlet and discharge OS&Y gate valves, stainless steel check and relief valve seats, stainless steel relief valve shafts and flange bolts. Ball valve test cocks shall be bronze body.

C. Pressure ratings shall be up to 175 psi and temperature ratings shall be up to 210 degrees F continuous.

D. Install unit per local code requirements and authorities having jurisdiction. Unless otherwise noted, install backflow preventers between 12 inches and 60 inches above finished floor.

E. Units shall be approved by ASSE 1013, UPC, UL, and shall be No. 909 with air gap fitting and inlet/outlet gate valves as manufactured by Watts Regulator, Conbraco, Wilkens, or as approved equal. Pipe discharge to nearest floor drain/floor sink. Provide minimum 18-inch clearance for servicing and testing.

F. Pipe discharge of backflow preventer full size to closest floor drain utilizing type "L" copper.

2.9. BACKFLOW PREVENTER (DOUBLE CHECK VALVE ASSEMBLY TYPE)

A. Furnish and install double check valve assembly backflow preventers at all cold water make-up connections to kitchen waste coolers, and where else indicated on contract documents.

B. The assembly shall consist of two positive seating check modules with captured springs and rubber seat discs. The check module sets and seat discs shall be replaceable.

C. Service of all internal components shall be through a single access cover secured with stainless steel bolts. The assembly shall include two resilient seated isolation valves and four top mounted, resilient seated test cocks.

1. Furnish each backflow preventer with the following accessories and options:

a. bronze strainer
b. quarter turn, full port, resilient seated ball valve shut-off
c. union connections

D. Provide minimum 18-inch clearance for servicing and testing.

E. The assembly shall meet the requirement of ASSE Std 1015 and AMCA Std C510.

F. Double check valve backflow preventers shall be Watts No. 007, Conbraco, Wilkens, Ancon, or approved equal.

2.10. BACKFLOW PREVENTER (DOUBLE CHECK VALVE ASSEMBLY TYPE) (VERTICAL TYPE)

A. Furnish and install vertical double check valve assembly backflow preventers at incoming water services and where else indicated on contract documents. Backflow preventers shall be suitable and listed for vertical installation.

B. The assembly shall consist of two positive seating check modules with captured springs and rubber seat discs. The check module sets and seat discs shall be replaceable.

C. Service of all internal components shall be through a single access cover secured with stainless steel bolts. The assembly shall include two resilient seated isolation valves and four top mounted, resilient seated test cocks.

D. Furnish each backflow preventer with the following accessories and options:

1. OS & Y Gate Valves.
2. Ball Valve Test Cocks.
3. Approval for vertical up flow installation.

E. Provide minimum 18-inch clearance for servicing and testing.

F. The assembly shall meet the requirement of ASSE Std 1012 and AMCA Std C510.

G. Double check valve backflow preventers shall be Watts No. 757, Conbraco, Wilkens, Ancon, or approved equal.

2.11. TRAP SEAL PRIMER VALVES (DIRECT CONNECT TO DOMESTIC WATER)

A. Supply type, Trap-Seal primer Valves

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. MIFAB, Inc.
b. PPP, Inc.
c. Sioux Chief Manufacturing Company, Inc.
d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
e. Watts Industries, Inc.; Water Products Div.

2. Standard: ASSE 1018.
3. Pressure Rating: 125 psig minimum
4. Body: Bronze.
5. Inlet and Outlet Connections: NPS ½ (DN15) threaded union, or solder joint.
6. Gravity Drain Outlet connection: NPS ½ (dn 15) threated or solder joint.
7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.
8. Distribution Unit: Outlet quantities required.
9. Backflow Preventer: Atmospheric vented drain chamber.

2.12. TRAP PRIMING STATION-AUTOMATIC TRAP PRIMER

A. Trap priming stations shall be Precision Plumbing Products, Inc., Electronic Trap Priming manifold Model PT, MIFAB, Sioux Chief, Watts, or approved equal. The manifold shall supply a minimum of 2 ounces of potable water per opening at 20 PSIG once in each 24 hour period. The Electronic Trap Priming Manifold must be capable of equally priming from 4 through 30 individual floor drain traps.

B. The unit shall be factory assembled and prepiped, and shall include a bronze body 3/4-inch female NPT WOG rated ball valve 3/4-inch, Water Hammer Arrestor, copper barrel with brass piston and type "L" copper sweat connection, electronic brass body 3/4-inch solenoid valve, and type "L" copper manifold with brass 2-inch compression fitting and orifice opening for precision water distribution to each floor drain trap. Unit shall be pre-piped with atmospheric vacuum breaker.

C. Electronic components shall include single point power connection at 120 volt 1 phase 60 hertz, manual over-ride switch, minimum 5 amp breaker, 24 hour geared timer with relay and 5 second dwell function. Separate water hammer arrestor can be provided outside station if integral arrestor is not available.

D. All components shall be factory assembled, tested and supplied in a 16 gauge steel enclosure suitable for surface or recess mounting, as indicated on contract drawings. In addition, all components must comply with nationally recognized standards. The Precision Plumbing Products Electronic Trap Priming Manifold shall be fully warranted for the life of the plumbing system.

E. When only a single trap primer is required, as in the case of a restroom with one floor drain in a toilet (or similar) the contractor may submit, in lieu of an electronic multiple station, a single station for review by the Engineer. The fixture serving the trap primer must be within 10' of the trap. Components shall be brass, bronze, and chrome, of the highest quality.

F. Access door shall be finished with a prime coat and fire rated where installed in a rated wall. Access door latch shall be Allen key type.

2.13. TRAP SEAL PRIMER VALVES

A. Provide and install one valve per trap, per floor drain on all remote floor drains. When installed on a fixture in a finished area, primer valve shall be concealed behind an access door. In mechanical rooms, mezzanines, penthouses, and all other locations indicated on contract drawings, priming lines shall be connected to automatic trap primer station. Trap seal primer valves shall be as manufactured by E&S, Precision Plumbing Products, Sioux Chief, Mifab, Watts, or approved equal.

B. Trap seal primer valves shall be ASSE 1018, water supply fed type with the following characteristics:

1. 125 psig minimum working pressure.
2. Bronze body with atmospheric - vented drain chamber.
3. Inlet and outlet connections: ½ inch NPS threaded or solder joint.
4. Gravity drain outlet connection: ½ inch NPS threaded or solder joint.
5. Finish: chrome plated

2.14. DOMESTIC WATER METER WITH ATC INTERLOCK CAPABILITIES

A. Furnish and install a bronze magnetic drive flanged turbo-water meter on incoming water service to building and where indicated. The water meter shall be Model WPX-211 as manufactured by Niagara, Rockwell, Hersey, or approved equal. Unit shall be sized and selected so as not to exceed the scheduled maximum pressure drop at design flow.

B. Main cases for all sizes shall be cast Water Works bronze. Size, model and direction of flow shall be cast, in raised characters, on both sides of the Main cases.

Operating Characteristics		
Meter Size	Low Flow (95 percent minimum)	Normal Range (100.0 +/- 1.5 percent)
2-inch	3	4 to 160
3-inch	4	5 to 350
4-inch	10	15 to 1000
6-inch	20	30 to 2000
10-inch	55	55 to 5500

1. 8-inch and 12-inch pipeline size applications can be accomplished by using the 6-inchand 10-inch size meters respectively with the appropriate tapered, concentric reducers.

C. Meters shall have performance capabilities of continuous operation up to the rated maximum flows as outlined above without affecting long term meter accuracy or causing undue wear. Meters shall also have a 25 percent flow capacity in excess of the maximum flows listed for intermittent flow demands.

D. The measuring chamber shall be of unitized construction (i.e., complete with measuring element, calibration device and register in one assembly). The measuring chamber shall be capable of operating within above listed accuracy limits without recalibration when transferred from one main case to another. The measuring element shall be mounted on a horizontal stationary shaft with sleeve bearings and be essentially weightless in water.

E. The register shall be permanently hermetically sealed; all registers of similar size and registration to have a standard ratio gear reduction so as to permit interchange ability. The register shall be assembled to measuring chamber in a tamper proof manner so removal can be made only after measuring chamber is removed from the maincase. Sweep hand reading and odometer wheel details will conform to American Water Works Standard C-701, as most recently revised.

F. All reduction gearing shall be enclosed in the permanently hermetically sealed register. The drive magnet shall be located in the measuring element, and the follower magnet shall be located inside the permanently hermetically sealed register. An intermediate magnetically active material shall be required to distribute the magnetic flux uniformly to the follower magnet, thereby improving the service life of the register's rotating components.

G. All meters shall operate without leakage, damage or malfunction up to a maximum operating pressure of 150 pounds per square inch.

H. The 6-inch and 10-inch size meters shall have external strainers as part of the meter package. Strainers shall have cover plate for inspection and removal of debris from the bronze screen without disturbing the pipeline.

I. Flanges on 2-inch size meters shall be oval faced and drilled on the horizontal axis with a bolt circle diameter of 4 ½ -inch. Thickness shall be as required for Class 125 round flanges. Flanges for 3-inch, 4-inch, 6-inch and 10-inch size meters shall be of the Class

125 round type, flat faced, and shall conform to ANSI 16.1 for specified diameter, drilling and thickness. Companion flanges, if required with the meters, shall consist of one standard cast iron flange, tapped with American Standard internal taper pipe threads, and one flanged coupling adapter. The type and outside diameter of connecting pipe shall be provided for appropriate gasket sizing. All bolts, nuts and gaskets shall be provided.

J. Turbine meters of similar design concept must be available for purchase in all of the sizes specified above. The turbine meters must have a minimum of five (5) years of satisfactory operating experience as marketable products. Limited experimental history is not acceptable. The meter manufacturer shall submit, in writing, a price schedule of its factory maintenance program for the measuring chambers.

K. The water meter shall be fully field insulated and jacketed to prevent condensation.

L. The water meter shall be provided with a high frequency pulse output device for interface with Automatic Temperature Control System. The Infrared Pulser shall be Model 860 as manufactured by Hersey or approved equal.

M. A Pulse to DC converter shall be supplied with the Infrared Pulser. The device shall convert pulses from a variety of liquid flow sensing devices to a 4-20mA output signal which is proportional to the flow rate. This output shall transmit flow rate data over long distances with no loss of accuracy. The converter shall be Model 1005 as manufactured by Hersey or approved equal.

N. At contractor's option a water meter provided by the ATC subcontractor may be utilized.

2.15. DOMESTIC WATER EXPANSION TANKS

A. Provide and install domestic water expansion tanks of size, capacity and as indicated on contract drawings. Domestic water expansion tanks shall be Therm-X-TROL as manufactured by AMTROL Inc., Flexcon, Wessels, Taco, Armstrong, or approved equal. Mount tank as detailed on the drawings.

B. Domestic water expansion tanks shall be specifically designed for use in potable water systems. Tanks shall be pre-charged to require pressure at the factory. The maximum working pressure shall be 150 psig. The maximum operating temperature shall be 200 degrees F. Expansion tanks shall contain removable FDA approved butyl bladder.

C. Before installation, Contractor shall adjust the tank air pre-charge pressures to equal city water pressure.

D. The tank must be constructed in accordance with Section VIII of the A.S.M.E. boiler and pressure vessel code and stamped 150 psig working pressure.

E. Accessories: Pressure gauge and air charging fitting, tank drain, pre-charge as indicated on contract drawings and factory installed clip angles.

2.16. DOMESTIC WATER BOOSTER PUMP SYSTEM (VARIABLE SPEED)

A. Product(s) Supplied

1. The authorized factory trained representative shall provide one prefabricated, completely integrated, variable speed pumping station designed to provide constant pressure, at required flow rates with automatic lead/lag capability. The pumping station shall be the AquaForce™ variable speed pumping station by Goulds Pumps, G&L Pumps, Grundfos, Bell and Gossett, Syncroflow "Iron Heart", Armstrong, QuantumFlo, Flopak, Hydronics Modules, VC Systems and Controls, or approved equal. The pumping station shall include complete duplex or triplex stainless steel pumps, with appropriate variable speed (pump specific) variable speed controllers. It is the successful vendor's responsibility to include all necessary appurtenances to provide for a complete, automatic, smooth operating and reliable pumping system. The manufacturer shall supply a complete set of general arrangement drawings, electrical power schematics and control schematics in the operations and service manual, to include the complete pump and variable speed controller instruction manuals. All equipment shall be supplied by a single supplier (unitary source) to ensure system component compatibility.

B. References:

1. American Water Works Association (AWWA)
2. American National Standards Institute (ANSI)
3. American Standards for Testing Materials (ASTM)
4. Hydraulic Institute (HI)
5. American Society of Mechanical Engineers (ASME)
6. Underwriters Laboratories (UL)
7. International Standards Organization (ISO)

C. System Description

1. The pump station shall utilize 2 (duplex) stainless steel G&L Pumps, end suction or vertical multistage in conjunction with the Aquavar® variable speed pump controller as manufactured by G&L Pumps, A Goulds Pumps Company or equivalent products such a Grundfos, Bell and Gossett, Syncroflow "Iron Heart", Armstrong, or approved equal. Appropriate check and shutoff valves, pressure transducers, suction/discharge piping, pump and electrical protection shall be integrated into the pump controller package. Provide the following options: Input line reactors, lightning protection, phase loss protection, low suction pressure switch, temperature relief, flexible suction/discharge flanged connection, and flow meter.

D. Conditions of Service

1. Refer to schedules on Contract Drawings for condition of service and performance criteria.
2. Total pumping station system friction loss shall not exceed 5 psig.

E. Sequence of Operation

1. The station shall receive a 4-20mA signal from each pressure transducer, as provided by the pumping station manufacturer. A pressure transducer shall be provided for each pump controller. This shall provide a complete lead/ lag system coupled with a true back-up control. The pressure transducer shall monitor system

discharge pressure and provide an analog signal (4- 20mA) to the pump control software, and allow the variable speed pump controller, to provide a variable Volts/ Hz output to the motor. Pressure transducer shall be remote mounted at the end of the distribution piping or logic shall be employed that adjusts the pressure setpoint to simulate the operation of a remote sensor. Once the pressure drops below the set system pressure, the pump shall start and provide system pressure (as determined by the station operator), if this pressure cannot be maintained by one pump, the next pump in sequence shall operate in a lead/lag capacity to provide the extra flow and pressure automatically without the use of additional panels or alternators. The sequence of the pumps shall be field adjustable, and completely automatic without additional panels or alternator controls. The variable speed pump controller shall be completely integrated with the VFD. Special type motors will not be allowed (see motor section). Pumps shall alternate based on elapsed run time. All program settings shall be based on centrifugal pump language and centrifugal pumps. Program settings must be field adjustable to provide on site adjustments. When the system experiences low demand, the variable speed pump controllers will reduce the speed of each pump, until demand has stopped. Pump controllers will stop each pump at zero demand, without the use of external switches or controls.

2. An additional high pressure sensor shall be provided to monitor discharge pressure at booster pump system discharge header. If discharge pressure at discharge header exceeds 80 psig (adjustable) booster pump shall de-energize and alarm sound.
3. During low demand the system shall automatically enter “sleep mode”, which will increase the system pressure to 5 psig above normal set point to force water into hydropneumatic tank to allow storage and complete system shut-down.

F. Submittals

1. Submit three copies of the following for approval:

    a. General elevation drawings, wiring diagram, pump curves, operating and maintenance manuals and parts list.
    b. Written certifications for listing with Nationally Recognized Testing Laboratory (NRTL) for the complete pumping system
    c. Operation and Maintenance Manuals for pumps, controllers and complete pumping station.

G. Quality Assurance

1. The pump station shall be furnished by a single supplier entity, who shall have responsibility for the complete pumping station.

H. Qualifications

1. Manufacturer shall demonstrate proof of financial responsibility with respect to pump station delivery and performance.
2. Upon request from the engineer the manufacturer shall provide proof or evidence of facilities, equipment and capabilities required to produce the specified station.
3. Provide pumping station certified testing as an option.

I. Scheduling

1. The pump station manufacturer shall provide the following:

   a. Estimated FOB delivery
   b. Estimated NET weights
   c. Unloading instructions
   d. Acceptance at site procedures
   e. Onsite storage and protection information and complete instruction manuals.

J. Warranty:

1. The manufacturer shall warrant the water pumping system to be free of defects in material and workmanship for one year (12 months) from date of authorized start-up, not to exceed eighteen (18) months from date of manufacturer's invoice. Complete terms and conditions shall be provided upon request.

K. Start-Up Service

1. When discharge piping, electrical connections, and electrical inspection have been completed, the pump station representative shall be contacted for start-up. A minimum one-week notice shall be given to manufacturer representative prior to scheduled start-up date. During start up, the complete pumping system shall be given a running test of normal start and stop, and fully loaded operating conditions. During this test, each pump shall demonstrate its ability to operate without undue vibration, or overheating, and shall demonstrate its general fitness for service. All defects shall be corrected and adjustments shall be made to the pumping station for satisfactory operation. System problems or concerns shall be corrected by the contractor or site station staff, in conjunction with the appropriate factory representative. Testing shall be repeated until satisfactory results are obtained, as determined by the engineer. Start-up assistance shall be provided and shall be at least one 8-hour day.

L. Station Manufacturer

1. The pumping system shall be manufactured by G&L Pumps, A Goulds Pumps, ITT Industries Company, Grundfos, Syncroflow "Iron Heart", Armstrong, Flopak, or approved equal. All systems shall be approved by the engineer prior to bid opening. The station shall be of the capacities as shown on the contract drawings. For consideration of a proposed equal system, the contractor shall furnish the following data to the engineer at least 10 days prior to the date of the bid opening:

   a. A complete specification for the pumping system proposed as an equal.
   b. A statement of full conformance to the following specifications signed by a corporate officer of the manufacturer.
   c. A general arrangement drawing showing overall dimensions and all piping layouts.
   d. Complete submittal data for all major equipment (pumps, motors, valves, electrical controls, etc.).
   e. An electrical schematic, that provides power and control wiring.

f. A copy of the appropriate Instruction Operation Manual (IOM) for the pump, pump controller and pumping station.
g. Location of closest factory trained service centers.
h. Manufacturer's system UL (or equal) file number.

M. Station Components

1. Pumps

a. Pumps shall be constructed of 304 or 316L stainless steel and be of centrifugal, vertical multi-stage or end suction design. Pumps shall be the manufactured product of a US manufacturer, producing and selling pumps for a minimum of 10 years. Pump case, impellers, diffusers, seal spring, inner bowls, seal spring, shaft sleeve and retainer clip shall all be manufactured from stainless steel. Shaft bushing shall be from ceramic. Mechanical seal assembly shall be constructed of Carbon/ Silicon Carbide/ Viton as standard. Seat elastomers and casing o-rings shall be from Viton. Shaft sleeve shall be from stainless steel. Tie rods and nuts shall be from zinc coated steel. Pump curve shall rise continuously to shut off head. Best efficiency point of pump shall lie between 70% and 80% of maximum flow capacity of the pump. Pump connections shall be NPT or ANSI flanged, either class 150 or class 300. Maximum pressure rating for class 150 flanges shall be 200 psi and for class 300 shall be 360 psi. Pump shall accept a standard NEMA C-face motor, or JM frame and shall not require a specialty motor with special thrust bearings or integrated VFD. Vertical multistage pumps shall have thrust balanced within the pump. All pumps used shall have a standard NEMA frame motor, and be readily available from manufacturer.

2. Station Base

a. The pump station base shall be designed and fabricated to provide proper structural support for all attached equipment, and provide anchor bolt support. The base shall supply sufficient rigidity to withstand the stresses of reasonable and competent transportation to site, offloading, installation, and operation. Main structural members shall be constructed from heavy weight ¼ inch or 3/8 inch flat steel with a reinforcing channel for larger stations. Steel base shall be shot blasted, primed, and then painted as per paint specification. Provisions shall be made in the station base for off-loading and handling the station at the site of installation. Base shall include steel plate mounted under pump and motor and shall be of compact design for most standard doorways.

3. Piping

a. All piping shall be constructed from 304 stainless steel, schedule 40 type or heavier pipe as required to maintain a 3 to 1 pressure safety factor (including 1/16 inch corrosion allowance). All piping shall be hydrostatically tested to a minimum 150% of maximum shutoff pressure generated by the pumping station. Suction and Discharge manifolds shall be designed and constructed for minimal friction loss and compact design for most standard doorways.

4. Valves

a. Pump isolation valves 2” and below shall be full-port ball valves. Full-port ball valves shall have a brass body, ball shall be chrome plated brass with brass stem. Valves shall be pressure rated to 600 psi WOG. Valves shall conform to MSS-SP-110. Ball valves shall be Watts® model FBV-3.

b. Valves 2½” and above shall be either lug-type butterfly valves or grooved-end butterfly or ball valves. Butterfly valves body shall be constructed of ductile iron with a polyphenylene sulfide coating. Butterfly valves disc shall be aluminum bronze with a 416SS shaft. Butterfly valves shall have lever operators. Butterfly valve face-to-face dimensions shall comply with MSS-SP-67. Butterfly valves shall be pressure rated to 200 psi. Butterfly valves shall be Watts model BF-03. Grooved-end butterfly valves shall be constructed of ductile iron with an elastomer coated ductile iron disc. Grooved-end butterfly valves shall be pressure rated to 300 psi. Grooved-end butterfly valves shall be Victaulic® model VIC-300. Grooved-end ball valves shall be constructed of ductile iron with a nickel-plated ball and stem. Grooved-end ball valves shall be pressure rated to 1000 psi for sizes 2½” - 3” and 800 psi for sizes 4” - 6”. Grooved-end ball valves shall have lever operators and shall be Victaulic Series 721.

5. Pump Check Valves

a. Each pump discharge shall be equipped with a spring-loaded non-slam silent check valve, appropriately sized to allow no greater than 5 psi of head loss at full station rated capacity. Check valves 2” and below shall have a brass body and PTFE Teflon seat. Check valves 2” and below shall be pressure rated to 400 psi WOG. Check valves 2” and below shall be WATTS Series 600. Wafer style valves shall be provided in sizes from 2½ to 10” for installation between ANSI B16.5 class 150 or class 300 steel flanges. Wafer check valves shall be Val-Matic® Series 1440 or 1800 and conform to AWWA standard C508 for leakage rates. The operation of the valve shall not be affected by the position of installation. When pump is retired, valve shall function to close tightly before flow is reversed, and reducing the possibility of water hammer or shock.

6. Pressure Gauges

a. Pressure gauges shall be liquid filled, bourdon tube type. Gauges shall be supplied for both the suction and discharge manifolds. All gauges shall be bottom mounted and shall be glycerin filled to reduce wear due to vibration. Accuracy shall be within ±1.5%. Gauge diameter shall be 2½”. Range shall be at least 30% higher than the highest pressure attainable from the pumps at shutoff head conditions. Gauges shall include stainless steel back and copper alloy internals. Pressure gauges shall be manufactured by WIKA® or Equal.

7. Bolts

a. All bolts used in the assembly of the pumping system shall be zinc plated to retard corrosion and shall be the proper size and gauge for rigid construction.

8. Motors

a. Motor(s) for the main pump(s) shall be of United States manufacture, C-face or JM frame type open drip proof or TEFC enclosures 1.15 service factor, Min class F insulation. Motors shall be wound for the starting configuration as called out in the technical data sheet. Design pump brake horsepower shall not exceed 100% of motor horsepower exclusive of service factor. The motor shaft shall be high-strength steel. Motors shall be as manufactured by Baldor®, or approved equal. Motors shall be wound with ISR (Inverter Spike Resistant) wire for use with VFD's. Motor manufacturer must provide letter of compatibility of motor with another type of variable frequency or variable speed drive.

b. Motor efficiencies shall be premium efficiency per NEMA standards.

N. Electrical Scope

1. Provide complete main fusible disconnect, variable speed pump controllers, pressure transducers, NEMA motors, instrumentation and controls to automatically start, stop and modulate pump speeds. To smoothly, efficiently and reliably provide pump variable flow rates at a constant discharge pressure. Pumping station shall provide full pump, motor and drive safety features needed to protect the equipment and piping system.

2. Main Fusible Disconnect Enclosure

a. Individual fusible disconnects shall be provided to completely isolate individual motors starting equipment from incoming power. Individual disconnects shall have a through door operator, and shall be sized as shown in the technical data sheet. Motor fusible disconnect panel shall be housed in a NEMA 4 enclosure with integral latches. The control enclosure shall be constructed of 12-gauge steel and the back plate assembly shall be constructed of 12-gauge steel. All indicating lights, reset buttons, individual selector switches and the operator interface device shall be mounted on enclosure door and also be rated NEMA 4. All internal components shall be mounted and secured to the removable back plate assembly with rigid steel brackets. Disconnects shall be manufactured by ABB Control Inc., Allen Bradley, A/C Tech, or approved equal.

3. The proposed booster pump electrical ampacity requirements cannot exceed scheduled values due to limitations of existing electrical supply.

O. Lightning and Surge Arrester Option

1. Individual fusible disconnects shall be provided to completely isolate individual motors starting equipment from incoming power. Individual disconnects shall have a through door operator, and shall be sized as shown in the technical data sheet. Motor fusible disconnect panel shall be housed in a NEMA 4 enclosure with integral latches. The control enclosure shall be constructed of 12-gauge steel and

the back plate assembly shall be constructed of 12-gauge steel. All indicating lights, reset buttons, individual selector switches and the operator interface device shall be mounted on enclosure door and also be rated NEMA 4. All internal components shall be mounted and secured to the removable back plate assembly with rigid steel brackets. Disconnects shall be manufactured by ABB Control Inc, Allen Bradley, A/C Tech, or approved equal.

P. Variable Frequency Drive

1. The pump controller shall be the Goulds Pumps Aquavar® or Aquavar CPC variable speed pump controller or approved equal. The Aquavar shall provide an adjustable carrier frequency with IGBT power switching, and utilize PWM technology. The drive shall provide noiseless operation of the driving motor, short circuit and ground protection, phase loss protection and work with controlled sinusoidal current synthesis and dynamic over current limitations. The Aquavar controller shall be one complete integrated unit including the variable frequency drive, programmable phase loss protection, pump control logic, and include a NEMA 1 (CPC) or NEMA 4 (motor mount version) enclosure. Additional control panels, PLC's or other external devices, shall NOT be necessary to accomplish complete pump programming and variable speed control of pump and motor. Standard variable frequency drives that do not incorporate pump control logic as the primary control software; programming and features directly applicable to centrifugal pump applications shall not be considered equal.
2. The pumping station controller shall provide a LCD two line display with 16 characters per line and programming keypad for data entry. Unit(s) shall utilize user-friendly front panel programming in three languages that displays pump and motor language in clear text. Three colored LED's shall signal 'power on', 'pump running' and 'fault'. Program settings shall be changeable and stored in nonvolatile memory. Program settings shall be retained in memory in the event of loss of power to the controller, without the use of a backup battery. System operating pressure shall be clearly displayed in PSI or feet of head for ease of use and to provide an operator friendly interface. Additional parameters, where applicable, shall be displayed in units consistent with pumping systems. Generic control systems adapted from other applications shall not be considered equal.
3. The settings and program in whole or part may be locked out with the use of an operator selectable password. Standard system hydraulic settings shall include at a minimum the following functions: loss of suction, lack of NPSHa, pump run-out protection, "dead-head" protection, constant pressure setting with variable flow capability, constant flow with variable TDH (pressure) capability, quadratic differential flow calculation, system curve compensation, multiple pump operation with alternation, pump starting point with allowable adjustable pressure drop, minimum speed with time delay, pressure of flow sensor error, overpressure shutdown, and low flow shutdown.

Q. Pressure Transducer

1. Pressure transducer shall be utilized for providing all pressure signals for the pump control logic. Pressure transducer shall be a solid-state bonded strain gage type with an accuracy of plus/minus 0.20% and constructed of 17-4 pH stainless steel. Transducer shall be rated for station discharge pressure as scheduled and shall provide gauge pressure output, rather than an absolute. Pressure transducer

constructed of plastic is not acceptable. Pressure transducer shall be 4-20mA analog type with 7- 33 VDC supply range and utilize a packard type connector to prevent moisture intrusion. Transducer shall be manufactured by Texas Instruments. Pressure transducer shall be remote mounted. Refer to Contract Drawings for locations.

R. Controls and Enclosure

1. The control panel with controls shall be built in accordance with the NEC, and shall comply with UL standards. Pump station manufacturer shall be authorized under UL508A to manufacture its own control panels, and the control panel shall be manufactured by the pump station manufacturer. All equipment and wiring shall be mounted within the enclosure and each device shall be labeled for proper identification. All adjustments and maintenance shall be accessible from the front of the control enclosure. A complete wiring circuit diagram and legend with terminals, components, and wiring completely identified shall be provided. Main disconnect shall be interlocked with door.

   a. Panel face switches and lights:
      i. Reset—Acknowledges pump station alarms.
      ii. Individual pump disconnects.
      iii. Individual pump run and alarm lights.
      iv. Alarm horn.
      v. Low suction pressure reset.
   b. The pump station, including electrical components and enclosure, shall be UL labeled as a completed assembly with manufacturer's UL label applied to the pump station.
   c. Refer to Division 23 Section, "Instrumentation and Controls for HVAC and Plumbing Systems" for additional interlock requirements with ATC system.

S. Finishes: Paint

1. Steel base and main disconnect panel stand shall be grit-blasted with #50 steel grit per SSPC-10 to a near white metal condition. The cleaned steel surfaces shall immediately thereafter be primed with an industrial grade primer to a thickness of 2½ to 3 mils epoxy primer. The finish coat shall be acrylic enamel to a thickness of no less than 3 mils. The control panel shall be dip cleaned, acid etched and neutralized, iron phosphate coated and painted with a finish coat of 1½ to 2 mils of polyurethane.

T. Start up and Training

1. After the station startup has been completed, but before the technician leaves the job site, a training session shall be given to the owner or to the owner's representative, familiarizing that person (operator) with the pumping system operation, maintenance and adjustments.

U. Warranty Requirements

1. Provided that proper maintenance has been performed by the operator or user

during warranty period, and a component failure occurs, the manufacturer shall provide the replacement part or component. Repairs done at manufacturer's expense must be pre-authorized. The start-up certificate must be on file with manufacturer to activate warranty. Manufacturer shall support a wide network of

2.17. PRE-PRESSURIZED DOMESTIC BOOSTER PUMP HYDROPNEUMATIC BLADDER TANKS

A. Provide and install pre-pressurized domestic booster pump hydropneumatic bladder tanks of size, capacity and arrangement as indicated on contract drawings. Pre-pressurized domestic booster pump hydropneumatic bladder tanks shall be FXA as manufactured by Wessels, Flexcon, Hydrocumulator, Taco, Bell & Gossett or approved equal. Mount tank as detailed on the drawings.

B. Pre-pressurized domestic booster pump hydropneumatic bladder tanks shall be specifically designed for use in potable domestic water booster pump systems. Tanks shall be pre-charged to required pressure at the factory. The minimum working pressure shall be rated for maximum suction pressure plus booster pump shut-off pressure. The maximum operating temperature shall be 240 degrees F. Pre-pressurized domestic booster pump hydropneumatic bladder tanks shall contain removable FDA approved butyl bladder. No water should come in contact with the walls of the tank.

C. Before installation, Contractor shall adjust the tank air pre-charge pressure to schedule valve.

D. The tank must be constructed in accordance with Section VIII of the A.S.M.E. boiler and pressure vessel code and stamped to scheduled working pressure.

E. Accessories: Pressure gauge and air charging fitting with guard, tank drain, precharge as indicated on contract drawing and ASME nameplate.

2.18. HIGH/LOW MIXING VALVES WITH CABINET

A. Furnish and install high/low thermostatic controller valves of the size, capacity and arrangement as scheduled on the contract drawings. Units shall be pre-piped and installed within a surface mounted cabinet.

B. Each unit shall consist of two (2) thermostatic controllers with swivel action check stops, removable cartridge with strainer, stainless steel piston and liquid fill thermal motor with bellows element mounted out of water, inlet manifold piping, pressure reducing valve (PRV), two (2) pressure gauges, two (2) ball valves, bi-metal dial thermometer (3-inch face, range 201 – 240 degrees F), wall bracket, connecting piping and fittings to cabinet limit.

C. All equipment and piping shall be finished in rough bronze and/or copper. Bottom supplies and top outlet. Field insulate all piping within the cabinet as specified in Division 22 Section, Plumbing Insulation.

D. Cabinet shall be surface mounted with 16 gauges body, white baked enamel finish, 12 gauge left hinged door with cylinder lock and key.

E. Complete unit shall be factory assembled and tested. Field insulate all piping within enclosure.

F. High/low mixing valves shall be Symmons, Lawler, Powers, Acorn, or approved equal.

G. High/low mixing valves must be piped per the manufacturer's recommendations.

H. High/low mixing valves shall be ASSE 1017 rated.

2.19. ICE MAKER COLD WATER INLET FILTER

A. Provide and install a cartridge type water filter on the cold water inlet to the kitchen ice maker as detailed on the contract drawings. Housing shall be constructed of PVC with 3/4-inch NPT connections. Heads shall be cast bronze nickel plated with nickel plated "T" handle cap nut. Unit shall have pet cock bottom drain. Housing shall contain two (2) 20 micron cartridge filters. The entire filter assembly shall be rated for 150 psig. Unit shall be capable of handling a minimum 6 gpm. Housing shall be as manufactured by Keystone or approved equal.

B. Install filter housing to allow access for service and filter replacement.

2.20. ELEVATOR PIT SUMP PUMP

A. Furnish and install an elevator pit submersible sump pump of the size, capacity and electrical characteristics as shown on the drawings. System shall include submersible pump, 2-inch discharge flange/piping, grate with cover, float switches, oil sensor, remote mounted control panel and control system. Pumps and accessories shall be by Stancor Oil Minder, Zoeller, Liberty, Bell & Gossett, or approved equal.

B. Pumps:

1. Pump Design: The pump shall be capable of handling clean water waste. The pump(s) shall be capable of handling liquids with temperatures to 104 degrees F continuous, 160 degrees F intermittent, and shall be capable of running dry for extended periods. Pump shall include thermal and overload protection.

C. Pump Construction:

1. The volute, seal plates, impeller and motor housing shall be constructed of high quality #304 stainless steel. The pump(s) shall be painted with a water based air dry enamel of 2.0 mil minimum thickness. All exposed hardware shall be 300 series stainless steel. The pump construction shall contain no points of critical clearance nor require periodic adjustment or replacement to maintain operating efficiency. Discharge connection shall be a standard 2-inch NPT in the vertical position. All gaskets shall be of the compression square ring type eliminating critical slip fits and the possibility of damage during service associated with sliding o-ring sealing arrangements.
2. The impeller shall be of the non-clog design with pump out vanes on the back side. The impeller shall be dynamically balanced to ISO G6.3 specifications.
3. The unit shall utilize a single mechanical shaft seal which shall operate in an oil atmosphere. The materials of construction shall be carbon for the rotating face and

ceramic for the stationary face, lapped and polished to a tolerance of one light band, 300 series stainless steel hardware, and all elastomer parts to be of Buna-N. The seal shall be commercially available and not a proprietary design of the manufacture.

4. The pump shall be designed to be non-overloading throughout the entire pump curve. The rotor and stator assembly shall be of the standard frame design and secured to the pump seal plate by four threaded fasteners allowing for easy serviceability. Motor designs incorporating shrink or press fit assembly between the stator and motor housing shall not be acceptable. The motor shall be constructed with the windings operating in a sealed environment containing clean dielectric oil, making it capable of operating in a totally, partially or non-submerged condition for extended periods of time without damage due to the heat being generated. Air-filled motors shall not be acceptable. The motor windings shall be of Class "F" insulation. The motor shall meet the standard NEMA design L for single phase and NEMA design B for three phase. The motor shaft shall be of 416 stainless steel. The lower bearing shall be of the single ball type to accept radial and thrust loads, and the upper bearing of the sleeve or ball design, for radial loads. Bearings shall operate in an oil bath atmosphere for superior life. Permanently lubricated bearings are not acceptable.
5. Thermal sensors shall be used on three phase units to monitor stator temperatures. The stator shall be equipped with a thermal switch embedded in the end coil of the stator winding. This shall be used in conjunction with external motor overload protection and wired to the control panel. Single phase shall have an overload switch on the motor windings and do not require any external protection. Three (3) phase motors shall include phase loss protection.
6. The pump shall be equipped with type neoprene jacketed power cable and connected to the motor via quick disconnect spade terminals length as required. Crimp connected cords are not acceptable. Heat shrink tubes shall be used to connect power cord leads with motor leads. A master heat shrink tube shall be provided and filled with epoxy to seal the outer cable jacket and the individual strands to prevent water from entering the motor housing. A secondary rubber pressure groment shall be provided as an additional sealing point and strain relief at the point of cable entry. Cable entry designs utilizing terminal boards to connect power cord leads with motor leads shall not be acceptable.
7. The sump grate shall be custom sized to accommodate the dimensions of the sump. Grate shall be galvanized steel and have openings for all pipes/conduits as required.

D. Pump Test:

1. The pump manufacturer shall perform the following inspections and tests in accordance with Hydraulic Institute type B standards before shipment from the factory.
2. A check of the motor voltage and frequency shall be made as shown on the name plate.
3. A motor and cable insulation test for moisture contents or insulation defects shall be made per UL criteria.
4. The pump shall be completely submerged and run to determine that the unit meets three pre-determined hydraulic performance points.
5. A written report shall be available showing the aforementioned tests have been performed in accordance with the specifications.

E. Start-Up:

1. The pump(s) shall be tested at start-up by a qualified representative of the manufacturer. A start-up report as provided by the manufacturer shall be completed before final acceptance of the pump(s).
2. Warranty: Two (2) years from substantial completion.

F. Float Level Controls:

1. Provide and install three (3) level controls as detailed on the drawings. Two (2) level controls shall be utilized for the pump operation and the remaining level control shall be utilized for high water level alarm. Level controls shall be provided in a pipe mounted configuration with 25 feet of cable. Level controls shall be pilot duty devices which shall control the function of motor load devices, contactors, motor starters and power relays, to automatically cycle pumps. Switches shall be rated at 4.5 Amps at 115 VAC RES, Provide pole and stainless steel clamps and hardware.
2. Where required, provide custom length of cables to accommodate distance between sumps and control panels where the minimum 25 feet length is insufficient.

G. Valves:

1. Provide and install discharge valves on the pump as detailed on the drawings. Ball check valves shall be provided with removable threaded plug and natural rubber ball. Valve body shall be ASTM class 30. Cast iron valve shall be able to withstand 150 psig.
2. Ball Valves:

   a. Ball valves shall be True Union Type manufactured of Type 1 Schedule 80 PVC with EPDM O-rings for superior chemical and corrosion resistance. Valves shall be quick disconnect type for ease of maintenance. Ball valves shall be suitable for pressures up to 150 psig.

H. Control Panel:

1. The pump manufacturer shall supply a completely self-contained motor control panel. The control panel shall be provide with short circuit and overload protection for the pump. Furnish control panel with 8 pin twist lock receptacle, dual solid state oil sensor relays with reliable sensitivity settings, over current relay, sensor probe, horn, alarm silencing switch, terminal board and remote monitoring contacts. Furnish sufficient cable between pump and control panel. Furnish sufficient cable and plug for the control panel.
2. The motor controls shall be housed in a NEMA 4X enclosure. The enclosure shall be formed of 16 or 14 gauge, G-90 galvanized steel, with all surfaces phophatized then finished inside and out with ANSI 61 gray polyester powder finish. The door shall be equipped with two galvanized hinges with stainless steel hinge pins. The enclosure shall have external mounting tabs for wall mounting.
3. A magnetic starter shall be provided for each pump motor. The starter shall be equipped with a three (3) pole bimetalic overload relay with ambient compensation and Class 10, quick trip heaters. Heaters must be properly sized for motor load.

The overload relay shall provide the terminals for connection of the pump motor cable.

4. A control transformer shall be provided to supply low voltage as required for the control circuit. The transformer shall be continuous duty machine tool type, size to meet the load requirements of the control circuit. The transformer primary shall be connected to the load side of the circuit breaker. One side of the secondary winding shall be grounded to the component mounting panel.
5. A terminal block shall be provided for connection of level controls, oil sensor, alarms, remote monitoring and other control wiring as required for proper pump installation.
6. Control panel shall be interlocked with floats and oil sensor to allow pumping of water while containing oil. Control panel shall be fully automatic and shall provide for an alarm and LED lights in the event of any of the following:

    a. Presence of oil in the sump.
    b. High water level.
    c. High amps.
    d. Locked rotor.

7. Furnish additional contacts/relays for remote monitoring of high water alarm and oil presence alarm on facility automatic temperature control system. Coordinate with Division 23 Section, Instrumentation and Controls of HVAC and Plumbing Systems.
8. The control panel shall be wired in accordance with all applicable requirements of the National Electrical Code. Control wiring shall be sixteen (16) AWG red for control circuits and white for neutral grounded conductors. Power wiring shall be a minimum of 14 AWG black. Each conductor shall be numbered. The ends of all wires shall be tinned with 60/40 lead tin alloy sold. All wiring shall be performed in a neat and orderly manner.

2.21. IN-LINE COLD WATER INLET FILTER

A. Provide and install a cartridge type water filter on the cold water inlet to the water heaters as detailed on the contract drawings. Housing shall be constructed of PVC with 3/4-inch or 1 inch NPT connections. Heads shall be white talc reinforced polypro head. Housing shall contain one (1) 10 micron cartridge filters. The entire filter assembly shall be rated for 150 psig with maximum 5 psig pressure drop. Unit shall be capable of handling a minimum 15 gpm. Cartridge shall be nominal 4” diameter, 20” long pleated polypropylene, pleated polyester or other NSF safe material as required to meet specified performance. Provide filter with wall mounting bracket. Housing shall be as manufactured by Keystone, AMTROL, Watts, ITT Water Equipment, Culligan, International, or approved equal.

B. Install filter housing to allow access for service and filter replacement.

C. Provide 5 spare cartridges. Document in writing that cartridges have been turned over to Owner and forward copy to the Architect.

2.22. GREASE INTERCEPTOR (OUTDOOR CONCRETE TYPE)

A. Furnish and install an underground concrete grease interceptor of the size, capacity, and arrangement as shown on the Contract Documents.

PART 3. EXECUTION

3.1. GENERAL INSTALLATION REQUIREMENTS

A. Install all equipment in accordance with manufacturer's instructions.

B. Install components plumb and level.

C. Cleanouts in vertical pipes shall be installed in tees near floor. Cleanouts in horizontal pipes shall be installed with wyes on long sweep quarter beds. Cleanouts punching water proofing membranes shall have flashing clamps. Cleanout access covers in dry wall or gypsum board shall be painted to match walls.

D. Extend cleanouts to finish floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at cleanout for rodding of drainage system.

E. Encase exterior cleanouts in concrete flush with grade.

F. Install water heaters in accordance with manufacturer's instructions and to AGA, NSF, ANSI/NFPA 54, UL requirements and Delaware Boiler and Pressure Vessel Safety Act and Regulations. For gas fired water heaters, conduct a combustion flue gas analysis. Submit flue gas analysis report to Engineer for review. Record and submit design and actual draft at appliance vent connection.

G. Coordinate with plumbing piping and related fuel piping, gas venting and electrical work to achieve a complete operating system.

H. Install domestic water storage tanks in accordance with manufacturer's instructions.

I. Provide painted steel pipe support for tanks independent of building structural framing members.

J. Clean and flush domestic water storage tanks after installation. Seal until pipe connections are made.

K. Support piping adjacent to all pumps such that no weight is carried on pump casings. Provide supports under elbows on pump suction and discharge line sizes 4 inches (100 mm) and over.

L. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitations, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

M. Align and verify alignment of base mounted pumps prior to start-up.

N. For sump pumps ensure shaft length allows sump pumps to be located minimum 24 inches (600 mm) below lowest invert into sump pit and minimum 6 inches (150) clearance from bottom of sump pit.

O. All plumbing, vents in exterior walls shall be offset a minimum of 3'-0" in ceiling at roof before penetration.

P. All plumbing vents within a 10'-0" radius of exhaust vents shall be extended to a height of 3'-0" above exhaust vent crown.

Q. All plumbing vents within a 10'-0" radius of any rooftop unit or intake louver shall be extended to a height of 3'-0" above fresh air intake.

R. Slopes and invert elevations of all interior piping shall be established before any piping is installed in order that proper slopes will be maintained. All piping shall be located and determined where to be run to avoid conflict with other trades.

S. Unless otherwise noted, all plumbing piping shall be routed as high as possible between bottom of roof joists and above ceiling to allow proper installation of ductwork, fire protection piping, conduits, etc.

T. Coordinate with Architectural Drawings before roughing in plumbing.

U. All openings in ceilings and plenum walls for plumbing shall be sealed air tight and protected with fire stop.

V. See site plan for extent of all piping leaving and entering building.

W. See domestic water riser diagrams for location of valves, shock absorbers, balance valves, etc.

X. Make proper HW, CW, recirculating, waste, and vent connections to all equipment even though all branch main, elbows and connections are not shown.

Y. Cleanouts shall be provided near base of each vertical waste or solid stack. Provide 18" minimum clearance for access.

Z. Domestic hot, cold and recirculating water piping shall be installed between ceiling and roof insulation.

AA. Unless otherwise noted, horizontal sanitary piping pitches shall be 1 percent.

BB. Unless otherwise noted, all domestic water piping and fire protection piping shall be installed on heated side of ceiling insulation.

CC. All piping and installation shall comply with all local and national plumbing codes. Test piping as required by plumbing code and authority having jurisdiction.

DD. For sizes of all domestic water piping see plumbing fixture schedule and domestic water riser diagrams.

EE. For sizes of all sanitary and vent piping see plumbing fixture schedule and sanitary/vent riser diagrams.

FF. Set fill pressure on airside of hydropneumatic tanks to the pressure required by the booster pump manufacturer to allow shut-down of booster pump set during periods of no flow.

3.2. DOMESTIC WATER HEATER INSTALLATION REQUIREMENTS

A. Install units on concrete bases, level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

B. Anchor units to substrate.

C. Install combustion air and flue vents as detailed on contract drawings. Terminate and install combustion air and flue vent piping per manufacturer's requirements.

D. Install condensate hose below exhaust elbow per manufacturer's requirements. Extend condensate hose continuous downward pitch and discharge into condensate neutralizer. Install lime chips in condensate neutralizer.

E. Install temperature and pressure relief valves in top portion of storage tank shells of units with storage. Use relief valves with sensing elements that extend into shells. Extend relief valve outlet with water piping in continuous downward pitch and discharge onto closest floor drain. Install union on relief valve discharge piping. Install automatic air vent at top of hot water supply piping with union ball valve.

F. Install pressure relief valves in water piping for units without storage. Extend relief valve outlet with water piping in continuous downward pitch and discharge onto closest floor drain.

G. Install vacuum relief valves in cold water inlet piping.

H. Install unit drain piping as indirect waste to spill into open drains or over floor drains. Install hose end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 22 Section, Plumbing Piping, Fittings and Valves for drain valves.

I. Install thermometers on unit inlet and outlet piping. Refer to Division 22 Section, Plumbing Piping, Fitting and Valves for thermometers. Install pressure gages on unit piping.

J. Fill unit with water. Install domestic water expansion tank and charge with air. Install piping adjacent to units to allow service and maintenance.

K. Connect hot and cold water piping with shutoff valves and unions. Connect hot water circulating piping with shutoff valve, check valve, and union.

L. Make connections with dielectric fittings where piping is made of dissimilar metal.

M. Electrical Connections: Power wiring is specified in Division 26 Sections. Arrange wiring to allow unit servicing.

N. Ground equipment

1. Tighten electrical connectors and terminals according to manufacturers published torque tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.Engage a factory authorized service representative to perform startup service.

O. In addition to manufacturer's written installation and startup checks, perform the following:

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment and retest until satisfactory results are achieved.
2. Verify that piping system tests are complete.
3. Check for piping connection leaks.
4. Check for clear relief valve inlets, outlets, and drain piping. Check operation of circulators.
5. Test operation of safety controls, relief valves, and devices. Energize electric circuits.
6. Adjust operating controls.
7. Adjust hot water outlet temperature settings. Do not set above 140 deg F 60 deg C unless piping system application requires higher temperature.

3.3. PLUMBING SPECIALTY INSTALLATION REQUIREMENTS

A. General: Install plumbing specialty components, connections, and devices according to manufacturer's written instructions.

B. Install backflow preventers of type, size, and capacity indicated, at each water supply connection to mechanical equipment and systems, and to other equipment and water systems as indicated. Comply with authorities having jurisdiction. Locate backflow preventers in same room as connected equipment. Install air gap fitting on units with atmospheric vent connection and pipe relief outlet drain to nearest floor drain. Do not install bypass around backflow preventer. Label all piping downstream of backflow preventers as "non-potable" water.

C. Field test all backflow preventers and submit test reports to Engineer. Furnish test kits as required for field testing.

D. Install pressure regulators with inlet and outlet shutoff valves and balance valve bypass. Install pressure gages on inlet and outlet.

E. Install strainers on supply side of each control valve, pressure regulator, and solenoid valve, and where indicated.

F. Install hose bibbs with integral or field installed vacuum breaker.

G. Install wall hydrants with integral or field installed vacuum breaker.

H. All hose bibs shall be mounted 18" above finished floor, unless otherwise specified.

I. All wall hydrants shall be mounted 24" above finished grade unless otherwise specified.

J. Install all roof hydrants 41 inches above finished roof.

K. Install trap seal primer valves with valve outlet piping pitched down toward drain trap a minimum of one percent and connect to floor drain body, trap, or inlet fitting. Adjust valve for proper flow. Install trap priming stations plumb and level with adequate access for servicing and maintenance.

L. For all trap primer pipes label the same as to the location of the floor drain served.

M. For floor drains located in toilet rooms and similar spaces where flush valves are utilized. Contractor may utilize trap primer line from flush valve tail piece.

N. Install backwater valves in building drain piping as indicated. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing. 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. For exterior installation provide handhole with hinged cover and top mounted to be flush with grade.

O. Fasten recessed, wall mounting plumbing specialties to reinforcement built into walls.

P. Secure supplies to supports or substrate.

Q. Install individual stop valve in each water supply to plumbing specialties. Use ball, gate, or globe valve if specific valve as appropriate is not indicated.

R. Install water supply stop valves in accessible locations.

S. 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.

T. Include wood blocking reinforcement for recessed and wall mounting plumbing specialties.

U. Install ball valves at all shock absorbers to allow removal for service/replacement.

3.4. WATER METER INSTALLATION REQUIREMENTS

A. Install water meters, piping, and specialties according to AWWA M6 and local utility's and Manufacturer’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 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.
3. Install detector type 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. Install roughing in piping and specialties for water meter installation according to utility's instructions and requirements.

B. Install power and control wiring from water meter to ATC system.

C. Field insulate and jacket water meter to prevent condensation.

D. Provide spare strainer screen for all water meters with integral strainers.

E. Install power wiring to water meter and encoder/reader.

3.5. FITTINGS FOR FIXTURES SUPPLIED BY OTHERS

A. Fixtures such as built in sink in counters and kitchen equipment are provided under other divisions of the specifications and are complete with strainer and tailpiece. Fittings, accessories and connection of these fixtures to the plumbing system are provided under this section.

B. Rough-in and final connection includes but is not limited to all domestic water, waste, and vent, gas systems. Furnish stops, strainers, vacuum breakers, and under counter insulation where not furnished under another Division of these specifications.

3.6. KITCHEN EQUIPMENT INSTALLATION

A. The kitchen equipment plumbing fixtures are provided under the Architectural Division of these specifications. Rough-in and final connection shall be provided under this Division. Coordinate final connection and rough-in dimensions with Architectural Contract drawings.

B. The rough-in requirements are as scheduled on the drawings. The equipment No's are per the kitchen equipment drawings.

C. Water Inlets:

1. Water inlets shall be located above the positive water level wherever possible to prevent siphoning of liquids into the water supply system. Wherever conditions shall require a submerged inlet, a suitable type of check valve (except in jurisdictions where check valves are prohibited) and vacuum breaker shall be placed on the fixture to prevent siphoning. Where exposed to view, piping and fittings shall be chrome-plated.

D. Drain Lines:

1. Plumbing Contractor shall provide and install indirect waste lines from equipment which will discharge into floor drains or safe wastes in accordance with Plumbing Rough-In plans, chrome-plated where exposed. Extend to a point at least 1-inch (or as required by local codes) above the rim of the floor drain, cut bottom on 45 degree angle and secure in position.
2. All horizontal piping lines shall be run at the highest possible elevation and not less than 6-inch above finished floor, through equipment where possible.
3. No exposed piping in or around fixtures or in other conspicuous places shall show tool marks of more than one thread at the fitting.
4. Provide suitable pressure regulating valves for all equipment with such components that might reasonably be expected to be affected over a period of time

by adverse pressure conditions.

E. Sealants:

1. Provide and apply sealant where kitchen equipment plumbing fixtures come in contact with walls and floors.
2. Sealant, shall conform to ASTM C920; type S Grade NS, Class 25, Use Nt, with characteristics that when fully cured and washed meets requirements of Food and Drug Administration Regulation 21 CFR 177.2600 and N.S.R. RTV-732 for use in areas where it comes in contact with food.
3. Dow-Corning #780 or General Electric "Silastic", or approved equal, in either clear or approved color to match surrounding surfaces and applied in accordance with manufacturers recommendations for a smooth, sealed finish.

3.7. TESTING

A. After plumbing fixtures are connected, all piping and fixtures shall be tested for operation and a smoke or peppermint test shall be made on all soil, waste and vent piping.

B. After the building has been occupied and the various equipment is in actual use, the Contractor shall make an operating test of all equipment at a time directed by the Engineer to determine that all contract requirements are met.

3.8. CLEANING AND STERILIZATION

A. After final testing for leaks, all potable water lines shall be thoroughly flushed, by plumbing contractor, to remove foreign material. Before placing the systems in service, sterilize the new water lines in accordance with local health department codes and at a minimum according to the following procedure:

1. Through a 3/4-inch hose connection in each branch main and building main, pump in sufficient sodium hypochlorite to produce a free available chlorine residual of not less than 200 ppm. Plumbing Contractor shall provide plumbing connections and power for pumping chlorine into system.
2. Proceed upstream from the point of chlorine application opening all faucets and taps until chlorine is detected. Close faucets and taps when chlorine is evident.
3. When chlorinated water has been brought to every faucet and tap with a minimum concentration of 200 ppm chlorine, retain this water in the system for at least three (3) hours.
4. CAUTION: Over-concentration of chlorine and more than three (3) hours of retention may result in damage to piping system. It is not necessary to retain chlorine in any system for twenty-four hours to achieve sterilization. AWWA states that 200 ppm chlorine for three hours is sufficient.
5. At the end of the retention period, no less than 100 ppm of chlorine shall be present at the extreme end of the system.
6. Proceed to open all faucets and taps and thoroughly flush all new lines until the chlorine residual in the water is less than 1.0 ppm.
7. Obtain representative water sample from the system for analysis by an independent and recognized bacteriological laboratory.
8. If the sample tested for coliform organisms is negative, a letter and laboratory report shall be submitted by the service organization to the Contractor, certifying

successful completion of the sterilization. Additionally, this report shall be forwarded to the Owner as well as be included in the O&M Manual.

9. If any samples tested indicate the presence of coliform organisms, the entire sterilization procedure shall be repeated.
10. Take precautions to avoid use of plumbing fixtures and domestic water systems during sterilization period. Place signs on all plumbing fixtures and outlets during sterilization period.

3.9. EXAMINATION

A. Verify that walls and floor finishes are prepared and ready for installation of fixtures.

B. Verify that electric power is available and of the correct characteristics.

3.10. PREPARATION

A. Review the Kitchen Equipment Consultant's equipment cut sheets. Confirm rough-in location and size of fixtures and openings prior to commencing work.

B. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

3.11. INTERFACE WITH OTHER PRODUCTS

A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.

3.12. CLEANING

A. At completion, clean plumbing equipment.

3.13. ELEVATOR PIT SUMP PUMP INSTALLATION REQUIREMENTS

A. Provide access space around pump for service and motor replacement.

B. Install all float wiring and water level controls.

C. Install all interlock wiring from pump to oil minder control panel and automatic temperature control system.

D. Furnish and install removable galvanized steel grate to match pit sump opening size.

E. Provide factory start-up and training.

F. Test/Balance Engineer to test pump and all controls and submit results in the TAB report.

3.14. DOMESTIC BOOSTER PUMP INSTALLATION REQUIREMENTS

A. Set up and adjust all sensors, control panels, alarms, and controls.

B. Provide factory authorized startup and training.

C. Interlock domestic booster pump control panel with ATC system as required to provide monitoring requirements indicated on the control diagram and points list. Coordinate with ATC subcontractor.

D. Test and Balance Contractor to test domestic booster pumps as specified.

E. Furnish, install, and interlock remote pressure sensor.

END OF SECTION

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COMMON WORK RESULTS FOR HVAC
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SECTION 23 05 00 – COMMON WORK RESULTS FOR HVAC

PART 1. GENERAL

1.1. SUMMARY

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Provide all labor, materials, equipment, and services necessary for and incidental to the complete installation and operation of all mechanical work.

C. Unless otherwise specified, all submissions shall be made to, and acceptances and approvals made by the Architect and the Engineer.

D. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions and accessories are not necessarily shown. Furnish and install all such items as may be required to fit the work to the conditions encountered. Arrange piping, ductwork, equipment, and other work generally as shown on the contract drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawings for approval in accordance with Submittals specified below. The right is reserved to make reasonable changes in location of equipment, piping, and ductwork, up to the time of rough-in or fabrication.

E. Conform to the requirements of all rules, regulations and codes of local, state and federal authorities having jurisdiction.

F. Coordinate the work under Division 23 with the work of all other construction trades.

G. Be responsible for all construction means, methods, techniques, procedures, and phasing sequences used in the work. Furnish all tools, equipment and materials necessary to properly perform the work in first class, substantial, and workmanlike manner, in accordance with the full intent and meaning of the contract documents.

1.2. PERMITS AND FEES

A. Obtain all permits and pay taxes, fees and other costs in connection with the work. File necessary plans, prepare documents, give proper notices and obtain necessary approvals. Deliver inspection and approval certificates to Owner prior to final acceptance of the work.

B. Permits and fees shall comply with the Division 01, General Requirements of the specification.

1.3. EXAMINATION OF SITE

A. Examine the site, determine all conditions and circumstances under which the work must be done, and make all necessary allowances for same. No additional cost to the Owner will be permitted for contractors' failure to do so.

B. Examine and verify specific conditions described in individual specifications sections.

C. Verify that utility services are available, of the correct characteristics, and in the correct locations.

1.4. CONTRACTOR QUALIFICATION

A. Any Contractor or Subcontractor performing work under Division 23 shall be fully qualified and acceptable to the Architect/Engineer and Owner. Submit the following evidence when requested:

1. A list of not less than five comparable projects which the Contractor completed.
2. Letter of reference from not less than three registered professional engineers, general contractors or building owners.
3. Local and/or State License, where required.
4. Membership in trade or professional organizations where required.

B. A Contractor is any individual, partnership, or corporation, performing work by contract or subcontract on this project.

C. Acceptance of a Contractor or Subcontractor will not relieve the Contractor or subcontractor of any contractual requirements or his responsibility to supervise and coordinate the work, of various trades.

1.5. MATERIALS AND EQUIPMENT

A. Materials and equipment installed as a permanent part of the project shall be new, unless otherwise indicated or specified, and of the specified type and quality.

B. Where material or equipment is identified by proprietary name, model number and/or manufacturer, furnish named item, or its equal, subject to approval by Engineer. Substituted items shall be equal or better in quality and performance and must be suitable for available space, required arrangement, and application. Submit all data necessary to determine suitability of substituted items, for approval.

C. The suitability of named item only has been verified. Where more than one item is named, only the first named item has been verified as suitable. Substituted items, including items other than first named shall be equal or better in quality and performance to that of specified items, and must be suitable for available space, required arrangement and application. Contractor, by providing other than the first named manufacturer, assumes responsibility for all necessary adjustments and modifications necessary for a satisfactory installation. Adjustments and modifications shall include but not be limited to electrical, structural, support, and architectural work.

D. Substitution will not be permitted for specified items of material or equipment where noted.

E. All items of equipment furnished shall have a service record of at least five (5) years.

1.6. FIRE SAFE MATERIALS

A. Unless otherwise indicated, materials and equipment shall conform to UL, NFPA and ASTM standards for fire safety with smoke and fire hazard rating not exceeding flame spread of 25 and smoke developed of 50.

1.7. REFERENCED STANDARDS, CODES AND SPECIFICATIONS

A. Specifications, Codes and Standards listed below are included as part of this specification, latest edition.

B. AABC - Associated Air Balance Council

C. ACCA - Air Conditioning Contractors of America

D. ADC - Air Diffusion Council

E. AGA - American Gas Association

F. AMCA - Air Movement and Control Association

G. ANSI - American National Standards Institute

H. ARI - Air Conditioning and Refrigeration Institute

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

J. ASME - American Society of Mechanical Engineers

K. ASPE - American Society of Plumbing Engineers

L. ASTM - American Society for Testing and Materials

M. CS - Commercial Standard

N. DNREC - Delaware Department of Natural Resources

O. FM - Factory Mutual

P. IBC - International Building Code

Q. IEEE - Institute of Electrical and Electronics Engineers

R. MSSP - Manufacturers Standards Society of the Valve and Fittings Industry

S. NEC - National Electrical Code

T. NEMA - National Electrical Manufacturers Association

U. NFPA - National Fire Protection Association

V. SMACNA - Sheet Metal and Air Conditioning Contractors National Association

W. TEMA - Tubular Exchanger Manufacturers Association

X. UL - Underwriters' Laboratories

Y. State of Delaware Fire Protection Regulations.

Z. All mechanical equipment and materials shall comply with the codes and standards listed in the latest edition of ASHRAE HVAC Applications Handbook, Chapter entitled Codes and Standards.

AA. State of Delaware Geothermal borefield Installation Requirements.

1.8. SUBMITTALS, REVIEW AND ACCEPTANCE

A. Equipment, materials, installation, workmanship and arrangement of work are subject to review and acceptance. No substitution will be permitted after acceptance of equipment or materials except where such substitution is considered by the Architect to be in best interest of Owner.

B. After acceptance of Material and Equipment List, submit six (6) copies or more as required under General Conditions of complete descriptive data for all items. Data shall consist of specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, wiring diagrams, installation instructions, and any other information necessary to indicate complete compliance with Contract Documents. Edit submittal data specifically for application to this project.

C. Thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission. Coordinate installation requirements and any electrical requirements for equipment submitted. Contractor shall be responsible for correctness of all submittals.

D. Submittals will be reviewed for general compliance with design concept in accordance with contract documents, but dimensions, quantities, or other details will not be verified.

E. Identify submittals, indicating intended application, location and service of submitted items. Refer to specification sections or paragraphs and drawings where applicable. Clearly indicate exact type, model number, style, size and special features of proposed item. Submittals of a general nature will not be acceptable. For substituted items, clearly list on the first page of the submittal all differences between the specified item and the proposed item. The contractor shall be responsible for corrective action and maintaining the specification requirements if differences have not been clearly indicated in the submittal.

F. Submit actual operating conditions or characteristics for all equipment where required capacities are indicated. Factory order forms showing only required capacities will not be acceptable. Call attention, in writing, to deviation from contract requirements.

G. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted. Use only final or corrected submittals and data prior to fabrication and/or installation.

H. For any submittal requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.

I. For resubmissions, the Contractor must address in writing all of the Engineer's comments on the original submission to verify compliance.

1.9. SHOP DRAWINGS

A. Prepare and submit shop drawings for all mechanical equipment, specially fabricated items, modifications to standard items, specially designed systems where detailed design is not shown on the contract drawings, or where the proposed installation differs from that shown on contract drawings.

B. Submit data and shop drawings including but not limited to the list below, in addition to provisions of the paragraph above. Identify all shop drawings by the name of the item and system and the applicable specification paragraph number and drawing number.

C. Every submittal including, but not limited to the list below, shall be forwarded with its own transmittal as a separate, distinct shop drawing. Grouping of items/systems that are not related shall be unacceptable.

D. Items and Systems

1. Access Doors/Panels including layouts and locations
2. Airflow Monitoring Stations
3. Air Handling Units
4. Air Distribution Systems
5. Air Separators
6. Antifreeze Fluids
7. Antifreeze Pressure Tanks
8. Automatic Air Vents
9. Automatic Temperature Control Systems and Equipment
10. Automatic Glycol Feed Systems & Pressure Tanks
11. Backwater Valves
12. Carbon Dioxide Sensors
13. Central Control and Monitoring Systems (CCMS) and Equipment
14. Chemical Feed Tank
15. Coordinated Drawings
16. Dewpoint Temperature Sensors
17. Differential Bypass Valves, Transmitters
18. Direct Buried Piping
19. Drip Pans
20. Dryer Duct Booster Fan
21. Duct Materials
22. Dual Temperature System Fluid Filter Housing and Filters
23. Electric Unit Heaters
24. Electric Radiant Heat Panels
25. Energy Recovery Ventilators
26. Equipment Rails
27. Expansion Loops
28. Expansion Tanks and Accessories

29. Exterior Equipment/Duct Piping Supports
30. Exterior Pipe Supports
31. Fans
32. Freeze Protection Pumps
33. Filters
34. Filter Housings/Mixing Boxes
35. Fire Stopping - Methods and Materials
36. Fire Dampers
37. Flow Measuring Stations
38. Fluid Filter Housings
39. Flushing/Cleaning Reports
40. Flowmeter and Primary Elements (Flow Fittings)
41. Geothermal Heat Pumps
42. Geothermal Exterior Piping
43. Geothermal Fluid Filter Housing and Filters
44. Geothermal Interior Piping
45. Grilles, Registers, Diffusers
46. Grout
47. Heat Pipes
48. Horizontal Recessed Cabinet Unit Heaters
49. Horizontal Electric Unit Heaters
50. Hydraulic Separator
51. Identification Systems
52. In-Line Circulators
53. Intake Hoods
54. Kitchen Make-up Air Units
55. Kitchen Ventilation System Units
56. Kiln Vent Hood
57. Louvers
58. Material and Equipment Lists
59. Operations and Maintenance Manuals
60. Packaged Water Source Heat Pump Rooftop Unit(s)
61. Pete’s Plugs
62. Pipe Enclosures
63. Pipe Guides and Anchors
64. Pipe Materials Including Itemized Schedules
65. Preliminary Testing and Balancing Reports
66. Pressure Relief Valves
67. Pressure Regulating Valves
68. Pressure Independent Control Valves
69. Pump Pressure Switches
70. Pumps
71. Radiant Heat Panels
72. Roof Curbs
73. Rooftop Units/Relief Air Fans
74. Screen shots of ATC System Graphics
75. Split System Heat Pumps, Ductless
76. Static Pressure Gauges
77. Static Pressure Sensors
78. Strainers

79. Test Certificates
80. Thermal Insulation Materials Include Table Summaries
81. Thermometers and Gauges
82. Variable Frequency Drive Motor Bearing Protective Rings
83. Variable Speed Drives
84. Vertical In-Line Pumps
85. Vertical Cabinet Unit Heaters
86. Vibration Isolation Materials
87. Water Heater Flue/Combustion Air Piping
88. Water to Water Heat Pumps
89. Water Treatment Services
90. Weatherproof Assembly Components
91. Wiring Diagrams, Flow Diagrams and Operating Instructions

E. Contractor, additionally, shall submit for review any other shop drawings as required by the Architect. No item shall be delivered to the site, or installed, until the Contractor has received a submittal from the Engineer marked Reviewed or Comments Noted. After the proposed materials have been reviewed, no substitution will be permitted except where approved by the Architect.

F. For any shop drawing requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.

1.10. SUPERVISION AND COORDINATION

A. Provide complete supervision, direction, scheduling, and coordination of all work under the Contract, including that of subcontractors.

B. Coordinate rough-in of all work and installation of sleeves, anchors, and supports for piping, ductwork, equipment, and other work performed under Division 23.

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

D. Coordinate electrical work required under Division 23 with that under Division 26. Coordinate all work under Division 23 with work under all other Divisions.

E. Supply services of an experienced (10 year minimum) and competent Project Manager to be in constant charge of work at site.

F. Where a discrepancy exists within the specifications or drawings or between the specifications and drawings, the more stringent (or costly) requirement shall apply until clarification can be obtained from the Engineer. Failure to clarify such discrepancies with the Engineer will not relieve the Contractor of the responsibility of conforming to the requirements of the Contract.

G. Failure of contractor to obtain a full and complete set of contract documents (either before or after bidding) will not relieve the contractor of the responsibility of complying with the intent of the contract documents.

H. Coordinate installation of large equipment requiring positioning before closing in building. Where required arrange for manufacturer to ship equipment in modules.

1.11. CUTTING AND PATCHING

A. Accomplish all cutting and patching necessary for the installation of work under Division 23. Damage resulting from this work to other work already in place, shall be repaired at Contractor's expense. Where cutting is required, perform work in neat and work¬manlike manner. Restore disturbed work to match and blend with existing construction and finish, using materials compatible with the original. Use mechanics skilled in the particular trades required.

B. Do not cut structural members without approval from the Architect or Engineer.

1.12. PENETRATION OF WATERPROOF CONSTRUCTION

A. Coordinate the work to minimize penetration of waterproof construction, including roofs, exterior walls, and interior waterproof construction. Where such penetrations are necessary, furnish and install all necessary curbs, sleeves, flashings, fittings and caulking to make penetrations absolutely watertight.

B. Where pipes penetrate roofs, flash pipe with Stoneman Stormtite, Pate or approved equal, roof flashing assemblies with skirt and caulked counter flashing sleeve.

C. Furnish and install pitch pockets or weather tight curb assemblies where required.

D. Furnish and install roof drains, curbs, vent assemblies, and duct sleeves specifically designed for application to the particular roof construction, and install in accordance with the manufacturer's instructions. The Contractor shall be responsible for sleeve sizes and locations. All roof penetrations shall be installed in accordance with manufacturer’s instructions, the National Roofing Contractors Association, SMACNA, and as required by other divisions of these specifications.

1.13. CONCRETE AND MASONRY WORK

A. Furnish and install concrete and masonry work for equipment foundations, supports, pads, and other items required under Division 23. Perform work in accordance with requirements of other applicable Divisions of these specifications.

B. Concrete shall test not less than 3,000 psi compressive strength after 28 days.

C. Grout shall be non-shrink, high strength mortar, free of iron of chlorides and suitable for use in contact with all metals, without caps or other protective finishes. Apply in accordance with manufacturer's instructions and standard grouting practices.

1.14. CONNECTIONS AND ALTERATIONS TO EXISTING WORK

A. Unless otherwise noted on the drawings, where existing mechanical work is removed, pipes, valves, ductwork, etc., shall be removed, including hangers, to a point below finished floors or behind finished walls and capped. Such point shall be far enough behind finished surfaces to allow for installation of normal thickness of required finish material.

B. Where work specified in Division 23 connects to existing equipment, piping, ductwork, etc., Contractor shall perform all necessary alterations, cuttings, fittings, etc., of existing work as may be necessary to make satisfactory connections between new and existing work, and to leave completed work in a finished and workmanlike condition.

C. Where the work specified under Division 23, or under other Divisions, requires relocation of existing equipment, piping, ductwork, etc., Contractor shall perform all work and make necessary changes to existing work as may be required to leave completed work in a finished and workmanlike condition. Where existing insulation is disturbed, replace insulation where removed or damaged equal to existing, in type, thickness, density, finish and thermal resistance (R-value) value.

D. Where the relocation of existing equipment is required for access or the installation of new equipment, the contractor shall temporarily remove and/or relocate and re-install as required to leave the existing and new work in a finished and workman like condition.

1.15. EXCAVATION AND BACKFILLING

A. General

1. Perform all necessary excavation, or installation of work under Division 23, in whatever materials or conditions encountered, using suitable methods and equipment.
2. Accurately establish required lines and grades and properly locate the work.
3. Determine the locations of all existing utilities before commencing the work.

B. Excavation: (Refer also to other portions of the specifications)

1. Excavate only the required elevations. If excavation is carried below the foundation lines or other required limits, backfill the excess with concrete.
2. Keep banks of trenches as nearly vertical as possible, and provide sheeting and/or shoring as required for protection of work and safety of personnel. Follow local, State, OSHA Guidelines.
3. Keep excavations dry. Protect excavations from freezing.

C. Backfilling: (Refer also to other portions of the specifications)

1. Backfill excavations to the required elevations and restore surfaces to their original or required conditions.
2. Backfill shall be similar material, free from objectionable matter such as rubbish, roots, stumps, brush, rocks and other sharp objects. Unless otherwise indicated, suitable material from the excavation may be used for backfill.
3. Carefully place and mechanically tamp backfill in layers not exceeding 12 inches loose thickness. Compact to 95 percent minimum.
4. Do not backfill against frozen material. Do not use frozen material for backfill.

1.16. DRIVE GUARDS

A. Provide safety guards on all exposed belt drives, motor couplings, and other rotating machinery. Provide fully enclosed guards where machinery is exposed from more than one direction.

B. When available, guards shall be factory fabricated and furnished with the equipment. Otherwise fabricate guards of heavy gauge steel, rigidly braced, removable, and finish to match equipment served. Provide openings for tachometers. Guards shall meet local, State and O.S.H.A. requirements.

1.17. VIBRATION ISOLATION

A. Furnish and install vibration isolators, flexible connections, supports, anchors and/or foundations required to prevent transmission of vibration from equipment, piping or ductwork to building structure. See Division 23 Section, “Vibration Control for HVAC, Plumbing and Fire Protection Equipment”.

1.18. ALTERNATES

A. Refer to Division 01 Section, “Alternates” for description of work under this section affected by alternates.

1.19. REFRIGERANT SYSTEM CAPS

A. For all exterior grade and roof mounted equipment containing refrigerant install lockable caps on service valves to prevent tampering. Lockable caps shall be Model NPR as manufactured by Rector Seal or approved equal. Provide Model NPR Novent screwdriver tool with swiveling tip. Caps shall be suitable and specific for the refrigerant type utilized.

1.20. DEFINITIONS

A. Approve - to permit use of material, equipment or methods conditional upon compliance with contract documents requirements.

B. Furnish and install or provide means to supply, erect, install, and connect to complete for readiness for regular operation, the particular work referred to.

C. Contractor means the mechanical contractor and any of his subcontractors, vendors, suppliers, or fabricators.

D. Piping includes pipe, all fittings, valves, hangers, insulation, identification, and other accessories relative to such piping.

E. Ductwork includes duct material, fittings, hangers, insulation, sealant, identification and other accessories

F. Concealed means hidden from sight in chases, formed spaces, shafts, hung ceilings, embedded in construction.

G. Exposed means not installed underground or concealed as defined above.

H. Invert Elevation means the elevation of the inside bottom of pipe.

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

J. Review - limited observation or checking to ascertain general conformance with design concept of the work and with information given in contract documents. Such action does not constitute a waiver or alteration of the contract requirements.

K. SCR: Silicon Controlled Rectifier: Solid state switching device to provide fast, infinitely variable proportional control.

L. ECM: Electronically Commutating Motor.

M. Building Line: Exterior wall of building.

1.21. MINIMUM EFFICIENCY REQUIREMENTS

A. All heating, ventilating, and air conditioning equipment shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.

B. All piping, ductwork, and equipment insulation shall comply with ASHRAE Standard 90.1, latest edition.

C. All mechanical devices, controls, accessories, and components shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.

D. Department of Energy (DOE) compliance: Pump manufacturers shall comply with US Department of Energy (DOE) energy conservation standard for "clean water pumps" 1-200 horse power, less than 459 feet of head and greater than 25 gpm. These pumps shall be evaluated using the Pump Energy Index (PEI) of equal to or lesser than 1.0. the PEI number shall appear on the pump name plate and shall be available for the record at http://er.pumps.org.

E. Where Energy Star certification exists for equipment utilized on this project, the equipment must be Energy Star certified. Provide Energy Star certification with submittals.

1.22. SYSTEM INTEGRATION

A. For all HVAC equipment specified to be provided with packaged controls and interfaced with the automatic temperature control system, provide system integration between the equipment manufacturer and the automatic temperature control subcontractor.

B. HVAC equipment submittals requiring system integration as defined above must identify all required system integration points.

C. HVAC equipment manufacturers must coordinate with ATC subcontractor regarding system integration prior to submitting on the equipment.

D. A system integration meeting must be arranged by the Mechanical Contractor and include, but not be limited to the systems integrator for the HVAC equipment manufacturer and the ATC Subcontractor. This portion of systems integration must occur prior to HVAC equipment being delivered to the project.

E. Once the HVAC equipment is on site, a second systems integration meeting must be arranged by the Mechanical Contractor to coordinate the packaged controls with the ATC system. The HVAC equipment manufacturer's representative familiar with system integration and the ATC subcontractor familiar with programming must be present.

F. A final system integrations meeting shall occur once all equipment is in place and ready for operation. The Mechanical Contractor, the HVAC equipment systems' integrator, and the ATC Subcontractor shall meet on site to jointly program, schedule, verify points, interlock devices, and fully set up all systems integration components.

G. All systems integration coordination, programming, and graphics must be completed prior to requesting commissioning and/or inspections by the Engineer of Record.

1.23. FUTURE ADDITIONS

A. Where future additions are indicated, size and install all piping to account for future additions. Furnish and install shut-off valves, flow meters, and balance valves in ceiling adjacent to future additions. Provide cap at the end of the piping. Arrange so that in the future the cap can be removed and shut-off valve opened to serve future addition without draining system.

1.24. COORDINATION WITH SMYRNA SCHOOL DISTRICT I.T. DEPARTMENT

A. All equipment that interfaces with the internet shall be coordinated with the Smyrna School District I.T. Department to verify that the same is suitable for use on the Smyrna School District IT infrastructure. Coordinate with the Smyrna School District I.T. Department regarding the allowable frequency bands to avoid interference with the Smyrna School District I.T. infrastructure.

1.25. VFD BYPASSES

A. When VFD's are specified with integral bypasses and the equipment manufacturer is not able to provide bypasses due to equipment space constraints, then the manufacturer must provide spare VFD's for each fan/pump.

1.26. A2L REFRIGERANT REQUIREMENTS

A. All refrigerants utilized on this project shall be lower flammability and lower toxicity refrigerants as defined by ASHRAE Standard 34-Designation and Safety Classification of Refrigerants. Per ASHRAE 34-2019, this project shall only utilize A2L refrigerants in HVAC equipment such as R-32 and R-454B.

B. Refrigerants classified as B-1, B2L, A2, B2, A3, and B3 shall not be utilized.

C. All scroll compressor products shall be manufactured in compliance with UL-60335-2-40.

D. All equipment including installations shall comply with ASHRAE 15-2022 requirements and International Mechanical Code requirements whichever is more stringent.

E. The installing contractor shall submit a declaration to the authority having jurisdiction that the refrigerant systems have been installed and tested per ASHRAE 15-2022.

PART 2. ELECTRICAL REQUIREMENTS

2.1. GENERAL MOTOR AND ELECTRICAL REQUIREMENTS

A. Furnish and install control and interlock wiring for the equipment furnished. In general, power wiring and motor starting equipment will be provided under Division 26. Carefully review the contract documents to coordinate the electrical work under Division 23 with the work under Division 26. Where the electrical requirements of the equipment furnished differ from the provisions made under Division 26, make the necessary allowances under Division 23. Where no electrical provisions are made under Division 26, include all necessary electrical work under Division 23.

B. All electrical work performed under Division 23 shall conform to the applicable requirements of Division 26 and conforming to the National Electrical Code. All wiring, conduit, etc., installed in ceiling plenums must be plenum rated per NFPA and the International Building Code.

C. Provide wiring diagrams with electrical characteristics and connection requirements.

D. Test Reports: Indicate test results verifying nominal efficiency and power factor for three phase motors larger than five (5) horsepower.

E. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof covering. For extended outdoor storage, remove motors from equipment and store separately.

F. All motors shall be furnished with visible nameplate indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor and efficiency.

G. Motors located in exterior locations, wet air streams, air cooled condensers, and outdoors shall be totally enclosed weatherproof epoxy-treated type.

H. Nominal efficiency and power factor shall be as scheduled at full load and rated voltage when tested in accordance with IEEE 112.

I. Brake horsepower load requirement at specified duty shall not exceed 85 percent of nameplate horsepower times NEMA service factor for motors with 1.0 and 1.15 service factors.

J. All single phase motors shall be provided with thermal protection: Internal protection shall automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature ratings of motor insulation. Thermal protection device shall automatically reset when motor temperature returns to normal range, unless otherwise indicated.

K. Where a motor disconnect is indicated downstream of a variable frequency drive (VFD) provide interlock wiring from the auxiliary contacts on the disconnect to the VFD to de-energize when the disconnect is turned "off".

L. Where equipment under this Division is specified with integral disconnecting means, the same shall be a single disconnecting means for disconnecting all ungrounded main power supply conductors that is capable of being locked in the open (“off”) position in accordance with the National Electrical Code and the local electrical inspector.

2.2. MOTORS AND CONTROLS

A. Motors and controls shall conform to the latest requirements of IEEE, NEMA, NFPA-70 and shall be UL listed. Motor sizes are specified with the driven equipment. Motor starting and control equipment is specified either with the motor which is controlled or in an electrical specification section. The Contractor is advised to consult all specification sections to determine responsibility for motors and controls.

B. Motors shall be designed, built and tested in accordance with the latest revision of NEMA Standard MG l.

C. Motors used with variable-frequency controllers shall have ratings, characteristics, and features coordinated with and approved by the variable frequency controller (drive) manufacturer. As a minimum the following shall apply to variable frequency controlled motors:

1. Motors shall be manufactured to withstand peak voltages of 1600 volts with .1 microsecond rise time per NEMA MG-1.
2. Critical vibration frequencies of motor shall not be within operating range of variable frequency controller output.
3. Temperature rise: Match rating for Class B insulation.
4. Insulation: Class F.
5. Thermal Protection: Conform to MG1 requirements for thermally protected motors.

D. Motors shall be suitable for use under the conditions and with the equipment to which applied, and designed for operation on the electrical systems specified or indicated.

1. Motor capacities shall be such that the horsepower rating and the rated full-load current will not be exceeded while operating under the specified operating conditions. Under no condition shall the motor current exceed that indicated on the nameplates.
2. Motor sizes noted in the individual equipment specifications are minimum requirements only. It is the responsibility of the equipment manufacturers and of the Contractor to furnish motors, electrical circuits and equipment of ample capacity to operate the equipment without overloading, exceeding the rated full-load current, or overheating at full-load capacity under the most severe operating service of this equipment. Motors shall have sufficient torque to accelerate the total WR2 of the driven equipment to operating speed.
3. Motors shall be continuous duty type and shall operate quietly at all speeds and loads.
4. Motors shall be designed for operation on 60 hertz power service. Unless otherwise specified or shown, motors less than ½ horsepower shall be single phase, and motors ½ horsepower and larger shall be 3 phase unless otherwise noted.
5. Motors shall be mounted so that the motor can be removed without removing the entire driven unit.

E. Single phase motors, smaller than 1/20 horsepower shall be ball or sleeve bearing; drip-proof, totally enclosed or explosion proof, as specified; 120 volts; permanent-split capacitor or shaded pole type. These motors shall not be used for general power purposes, and shall only be provided as built-in components of such mechanical equipment as fans, unit heaters, humidifiers and damper controllers. When approved by the Engineer, deviations from the specifications will be permitted as follows:

1. Open motors may be installed as part of an assembly where enclosure within a cabinet provides protection against moisture.
2. Motors used in conjunction with low voltage control systems may have a voltage rating less than 115 volts.

F. Single phase motors, greater than 1/20 horsepower and less than ½ horsepower shall be ball bearing; drip-proof, totally enclosed or explosion proof, as specified, with Class A or B insulation, as standard with the motor manufacturer; 115 or 120/208/240 volts as required; capacitor start-induction run, permanent split capacitor, or repulsion start-induction run type with minimum efficiency of 70 percent and a minimum full load power of 77 percent.

G. Except as otherwise specified in the various specification sections, 3 phase motors 60 horsepower and smaller shall be NEMA design B squirrel cage induction type meeting the requirements of this paragraph. Motors shall be drip-proof, totally enclosed or explosion proof, as specified or indicated. Insulation shall be Class B or F, at 40 degrees C ambient temperature. Drip-proof motors shall have a 1.15 service factor and totally enclosed and explosion proof motors shall have a service factor of 1.00 or higher. Motors specified for operation at 480, 240, and 208 volts shall be nameplated 460, 230, 200 volts, respectively. Efficiencies and percent power factor at full load for three phase motors shall be not less than the values listed below for premium efficiency motors:

MOTOR NAMEPLATE	MINIMUM PERCENT EFFICIENCY AT NOMINAL SPEED AND RATED LOAD	MINIMUM PERCENT POWER FACTOR
1HP and above to	85.5 percent	84 percent
1-½ HP	86.5 percent	85 percent
2HP	86.5 percent	85 percent
3HP	89.5 percent	86 percent
5HP	89.5 percent	87 percent
7½ HP	91 percent	86 percent
10HP	91.7 percent	85 percent

MOTOR NAMEPLATE	MINIMUM PERCENT EFFICIENCY AT NOMINAL SPEED AND RATED LOAD	MINIMUM PERCENT POWER FACTOR
15HP	93.0 percent	85 percent
20HP	93.0 percent	86 percent
25HP	93.6 percent	85 percent
50HP and above	94.5 percent	88 percent
60 HP	95.0 percent	90 percent
75HP	95.0 percent	90 percent
100 HP	95.4 percent	90 percent
125 HP	95.8 percent	95 percent
150 HP and above	96.0 percent	95 percent

H. Three phase motors ½ HP or greater shall be the Duty Master XE by Reliance Electric Company, Super-E Premium Efficiency of Baldor Motor and Drives, E-plus Efficient Standard Duty Motor of the Electric Motor Division of Gould, Inc., the MAC II High Efficiency motor of Westinghouse Electric Corp., the equivalent product of General Electric, or approved equal.

I. For motors serving equipment being controlled by a variable speed drive, motor shall be premium efficiency inverter duty rated.

J. Motor frames shall be NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast-iron or aluminum with steel inserts.

K. Control of each motor shall be manual or automatic as specified for each in the various mechanical sections. In general, and unless otherwise specified for a particular item in the various mechanical sections of the specifications, motor starters and controls shall be specified and provided under the various electrical sections of these specifications.

L. Provide manufacturer's warranty for all motors for minimum of 5 years including all labor and materials.

2.3. MOTOR INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install securely on firm foundation. Mount ball bearing motors to support shaft regardless of shaft position.

C. Check line voltage and phase and ensure agreement with nameplate. Check that proper thermal overloads have been installed prior to operating motors.

D. Use adjustable motor mounting bases for belt-driven motors.

E. Align pulleys and install belts.

F. Tension belts according to manufacturer’s written instructions.

2.4. WIRING DIAGRAMS

A. The Contractor is responsible for obtaining and submitting wiring diagrams for all major items of equipment.

B. Wiring diagrams shall be provided with shop drawings for all equipment requiring electric power.

C. Provide wiring diagrams for all major mechanical items of equipment to electrical contractor and ATC subcontractor for coordination.

2.5. VARIABLE FREQUENCY DRIVE MOTOR BEARING PROTECTIVE RINGS:

A. For all motors driven by a variable frequency PWM drive include a maintenance free, circumferential, conductive micro fiber shaft grounding ring to discharge shaft currents. Grounding rings shall be manufactured by AEGIS SGR or approved equal.

B. Furnish units with two (2) year warranty.

C. Size and select Bearing Protective Rings per the manufacturer requirements based on the motor size, shaft diameter, and shaft shoulder length. For motors with slingers furnish and install NEMA /IEC kit as required.

D. Furnish and apply Colloidal silver shaft coating to all shafts with Bearing Protective Rings to improve shaft voltage discharge capability.

2.6. ENCLOSURES

A. Electrical enclosures including factory provided enclosures, field provided and installed enclosures, and automatic temperature control system enclosures shall be as follows:

1. Dry Interior Locations: NEMA 1.
2. Damp/Wet Locations, Including Exterior Locations: NEMA 3R.
3. Corrosive Locations, Including Chemical Storage Rooms and Similar Space: NEMA 4X.

PART 3. EXECUTION

3.1. EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to provide maximum possible headroom, if 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 Architect.

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

D. 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.

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

F. Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.

G. Do not install equipment, ductwork, or piping over electrical gear, electrical panels, motor controllers, and similar electrical equipment. Install equipment, ductwork, and piping to maintain clear space above and in front of all electrical components per the National Electric Code.

3.2. SUPPORTS, HANGERS AND FOUNDATIONS

A. Provide supports, hangers, braces, attachments and foundations required for the work. Support and set the work in a thoroughly substantial and workman-like manner without placing strains on materials, equipment, or building structure, submit shop drawings for approval. Coordinate all work with the requirements of the structural division.

B. Supports, hangers, braces, and attachments shall be standard manufactured items or fabricated structural steel shapes. All interior hangers shall be galvanized or steel with rust inhibiting paint. For un-insulated copper piping provide copper hanger to prevent contact of dissimilar metals. All exterior hangers shall be constructed of stainless steel utilizing stainless steel rods, nuts, washers, bolts, etc.

C. Concrete housekeeping pads and foundations shall be not less than 4 inches high and shall extend a minimum of 6 inches beyond equipment bases. Provide wire-mesh reinforcement; chamfer exposed edges and corners; and finish exposed surfaces smooth.

3.3. PROVISIONS FOR ACCESS

A. The contractor shall provide access panels and doors for all concealed equipment, valves, strainers, dampers, filters, controls, control devices, cleanouts, fire dampers, damper operators, traps, and other devices requiring maintenance, service, adjustment, balancing or manual operation.

B. Where access doors are necessary, furnish and install manufactured painted steel door assemblies consisting of hinged door, key locks, and frame designed for the particular wall or ceiling construction. Properly locate each door. Door sizes shall be a minimum of 12 inches x 12 inches for hand access, 18 inches x 18 inches for shoulder access and 20 inches x 30 inches for full body access where required. Review locations and sizes with Architect prior to fabrication. Provide U.L. approved and labeled access doors where installed in fire rated walls or ceilings. Doors shall be Milcor Metal Access Doors as manufactured by Inland-Ryerson, Mifab, or approved equal.

1. Acoustical or Cement Plaster: Style B
2. Hard Finish Plaster: Style K or L
3. Masonry or Dry Wall: Style M

C. Where access is by means of liftout ceiling tiles or panels, mark each ceiling grid using small color-coded and numbered tabs. Provide a chart or index for identification. Place markers within ceiling grid not on ceiling tiles.

D. Access panels, doors, etc. described herein shall be furnished under the section of specifications providing the particular service and to be turned over to the pertinent trade for installation. Coordinate installation with installing contractor. All access doors shall be painted in baked enamel finish to match ceiling or wall finish. Label inside of access door as to what it serves.

E. Submit shop drawings indicating the proposed location of all access panels/doors. Access doors in finished spaces shall be coordinated with air devices, lighting and sprinklers to provide a neat and symmetrical appearance.

F. Where access doors are installed in wet locations (i.e. shower rooms, toilet rooms, kitchens, dishwasher rooms, can wash rooms, and similar spaces, etc…) provide aluminum access doors/frames.

3.4. PAINTING AND FINISHES

A. Provide protective finishes on all materials and equipment. Use coated or corrosion-resistant materials, hardware and fittings throughout the work. Paint bare, untreated ferrous surfaces with rust-inhibiting paint. All exterior components including supports, hangers, nuts, bolts, washers, vibration isolators, etc. shall be stainless steel.

B. Clean surfaces prior to application of insulation, adhesives, coatings, paint, or other finishes.

C. Provide factory-applied finishes where specified. Unless otherwise indicated factory-applied paints shall be baked enamel with proper pretreatment.

D. Protect all finishes and restore any finishes damaged as a result of work under Division 23 to their original condition.

E. The preceding requirements apply to all work, whether exposed or concealed.

F. Remove all construction marking and writing from exposed equipment, ductwork, piping and building surfaces. Do not paint manufacturer's labels or tags.

G. All exposed ductwork, piping, equipment, etc. shall be painted. Colors shall be as stated in this division or as selected by the Architect and conform to ANSI Standards.

H. All exterior roof mounted ductwork, equipment, piping, breeching, and vents shall be painted to match roof in color as selected by Architect.

I. All exposed ductwork, piping, equipment, etc. in finished spaces shall be painted. Colors shall be as selected by the Architect and conform to ANSI Standards.

J. All exposed ductwork, piping, equipment, etc., in Mechanical Rooms, Geothermal Pump Equipment Rooms, Penthouses, Fire Pump Rooms, Mezzanines, and Storage where PVC jacketed shall not require painting. Label and identify and color code as specified.

K. Paint perimeter of all housekeeping pads and inertia bases safety yellow.

3.5. CLEANING OF SYSTEMS

A. Thoroughly clean systems after satisfactory completion of pressure tests and before permanently connecting fixtures, equipment, traps, strainers, and other accessory items. Blow out and flush piping until interior surfaces are free of foreign matter.

B. Flush piping in re-circulating water systems to remove cutting oil, excess pipe joint compound, solder slag and other foreign materials. Do not use system pumps until after cleaning and flushing has been accomplished to the satisfaction of the Engineer. Employ chemical cleaners, including a non-foaming detergent, not harmful to system components. After cleaning operation, final flushing and refilling, the residual alkalinity shall not exceed 300 parts per million. Submit a certificate of completion to Engineer stating name of Service Company used.

C. Maintain strainers and dirt pockets in clean condition.

D. Clean fans, ductwork, enclosures, registers, grilles, and diffusers at completion of work.

E. Install filters of equal efficiency to those specified in permanent air systems operated for temporary heating during construction. Replace with clean filters as specified prior to acceptance and after cleaning of system.

F. Pay for labor and materials required to locate and remove obstructions from systems that are clogged with construction refuse after acceptance. Replace and repair work disturbed during removal of obstructions.

G. Leave systems clean, and in complete running order.

H. All HVAC piping/equipment strainers must be pulled and cleaned prior to substantial completion. In addition six (6) months after substantial completion all HVAC piping/equipment strainers must be pulled and cleaned a second time. Document and submit verification of strainer cleaning to Engineer, Owner, and Construction Manager.

3.6. COLOR SELECTION

A. Color of finishes shall be as selected by the Architect.

B. Submit color of factory-finished equipment for acceptance prior to ordering.

3.7. PROTECTION OF WORK

A. Protect work, material and equipment from weather and construction operations before and after installation. Properly store and handle all materials and equipment.

B. Cover temporary openings in piping, ductwork, and equipment to prevent the entrance of water, dirt, debris, or other foreign matter. Deliver pipes and tubes with factory applied end caps.

C. Cover or otherwise protect all finishes.

D. Replace damaged materials, devices, finishes and equipment.

E. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, where stored inside.

F. Provide moisture protection for ductwork in areas which are not under roof or where ductwork would be exposed to rainwater.

3.8. OPERATION OF EQUIPMENT

A. Clean all systems and equipment prior to initial operation for testing, balancing, or other purposes. Lubricate, adjust, and test all equipment in accordance with manufacturer's instructions. Do not operate equipment unless all proper safety devices or controls are operational. Provide all maintenance and service for equipment that is authorized for operation during construction.

B. Where specified, or otherwise required, provide the services of the manufacturer's factory-trained servicemen or technicians to start up the equipment. Where factory start-up of equipment is not specified, provide field start-up by qualified technician.

C. Submit factory start-up sheets or field start-ups sheets for all equipment prior to the commencement of testing and balancing work. Testing and balancing work shall not commence until start-up reports have been completed, reviewed by Engineer and forwarded to Testing and Balancing Agency.

D. Do not use mechanical systems for temporary services or temporary conditioning during construction, unless approved by Owner in writing. Refer to Division 01 Section "Temporary Facilities and Controls" for temporary heating/cooling during construction.

E. Upon completion of work, clean and restore all equipment to new conditions; replace expendable items such as filters.

3.9. DEMONSTRATION AND TRAINING VIDEO RECORDINGS

A. General: Record demonstration and training video recordings. Record each training module separately.

1. At beginning of each training module, record each chart containing learning

objective and lesson outline.

B. Video Recording Format: Provide high-quality color video recordings with menu navigation in format acceptable to Engineer

C. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to show area of demonstration and training. Display continuous running time.

D. Narration: Describe scenes on video recording by audio narration by microphone while video recording is recorded. Include description of items being viewed.

E. Transcript: Provide a transcript of the narration. Display images and running time captured from videotape opposite the corresponding narration segment.

3.10. IDENTIFICATIONS, FLOW DIAGRAMS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS

A. Contractor shall submit for approval schematic piping diagrams of each piping system installed in the building. Diagrams shall indicate the location and the identification number of each valve in the particular system. Following approval by all authorities, the diagrams shall be framed, mounted under safety glass and hung in each Mechanical Room where directed. Contractor shall deliver the tracing or sepia from which the diagrams were reproduced to the Owner.

B. All valves shall be plainly tagged. For any bypass valves, install sign indicating valve position as “Normally Open” or “Normally Closed” as required.

C. All items of equipment, including motor starters, disconnects and ATC panels shall be furnished with white on black plastic permanent identification cards. Lettering shall be a minimum of ¼ inch high. Identification plates shall be secured, affixed to each piece of equipment, starters, disconnects, panels by screw or adhesive (tuff bond #TB2 or as approved equal).

D. Provide six (6) copies of operating and maintenance instructions for all principal items of equipment furnished. This material shall be bound as a volume of the Record and Information Booklet as hereinafter specified.

E. All lines piping and ductwork installed under this contract shall be stenciled with direction of flow arrows and with stenciled letters naming each pipe and ductwork and service. Refer to Division 23 Section, “HVAC Piping, Fittings, Valves, Etc.” and Division 23 Section, “HVAC Air Distribution”. Color-code all direction of flow arrows and labels. In finished spaces omit labeling and direction of flow arrows. Paint in color as selected by Architect.

F. Submit list of wording, symbols, letter size, and color coding for mechanical identification. Submit samples of equipment identification cards, piping labels, ductwork labels, and valve tags to Engineer for review prior to installation.

G. Provide at least 24 hours of straight time instruction to the operating personnel. Time of instruction shall be designated by the Owner. Additional instruction time for the automatic temperature control (ATC) system is specified in Division 23 Section, “Instrumentation & Controls of HVAC & Plumbing Systems”.

H. Contractor shall demonstrate Sequences of Operation of all equipment in presence of Owner's representative, Engineer, and ATC subcontractor.

3.11. WALL AND FLOOR PENETRATION

A. All penetrations of partitions, ceilings, roofs and floors by ducts, piping or conduit under Division 23 shall be sleeved, sealed, and caulked airtight for sound and air transfer control. Penetrations of mechanical room partitions, ceilings, and floors shall be as specified in Division 23 Section, "Vibration Control for HVAC, Plumbing and Fire Protection Equipment".

B. All penetration of fire rated assemblies shall be sleeved, sealed, caulked and protected to maintain the rating of the wall, roof, or floor. Fire Marshal approved U.L. assemblies shall be utilized. See Division 07 Section, "Fire Protection, HVAC & Plumbing Penetration Firestopping".

C. Where piping extends through exterior walls or below grade, provide waterproof pipe penetration seals, as specified in another division of these specifications.

D. Provide pipe escutcheons and duct flanges for sleeved pipes and ducts in finished areas.

E. Piping sleeves:

1. Galvanized steel pipe, standard weight where pipes are exposed and roofs and concrete and masonry walls. On exterior walls provide anchor flange welded to perimeter.
2. Twenty-two (22) gauge galvanized steel elsewhere.

F. Ductwork sleeves: 20 gauge galvanized steel.

G. Extend all floor sleeves through floor at least 3/4-inches above finished floor, caulk sleeve the entire depth and furnish and install floor plate.

H. Sleeves for penetrations in kitchen and food service areas shall finish .375 inches above floor or flush with wall surfaces and be neatly pointed up to fit snuggly against floor or wall material.

3.12. RECORD DRAWINGS

A. Upon completion of the mechanical installations, the Contractor shall deliver to the Architect one complete set of prints of the mechanical contract drawings which shall be legibly marked in red pencil to show all changes and departures of the installation as compared with the original design. They shall be suitable for use in preparation of Record Drawings.

B. Contractor shall incorporate all sketches, addendums, value engineering, change orders, etc., into record drawings prior to delivering to Architect.

3.13. WARRANTY

A. Contractor's attention is directed to warranty obligations contained in the GENERAL

CONDITIONS.

B. The above shall not in any way void or abrogate equipment manufacturer's guarantee or warranty. Certificates of equipment manufacturer's warranties shall be included in the operations and maintenance manuals.

C. The Contractor guarantees for a two (2) year period from the time of final acceptance by the Owner.

1. That the work contains no faulty or imperfect material or equipment or any imperfect, careless, or unskilled workmanship.
2. That all work, equipment, machines, devices, etc. shall be adequate for the use to which they are intended, and shall operate with ordinary care and attention in a satisfactory and efficient manner.
3. That the contractor will re-execute, correct, repair, or remove and replace with proper work, without cost to the Owner, any work found to be deficient. The contractor shall also make good all damages caused to their work or materials in the process of complying with this section. Contractor shall repair and/or replace any/all damage to finishes and furniture resulting from their corrective work.
4. That the entire work shall be water-tight and leak-proof.

3.14. LUBRICATION

A. All bearings, motors, and all equipment requiring lubrication shall be provided with accessible fittings for same. Before turning over the equipment to the Owner, the Contractor shall fully lubricate each item of equipment, shall provide one year's supply of lubricant for each, and shall provide Owner with complete written lubricating instructions, together with diagram locating the points requiring lubrication. Include this information in the Record and Information Booklet.

B. In general, all motors and equipment shall be provided with grease lubricated roller or ball bearings with Alemite or equal accessible or extended grease fittings and drain plugs.

3.15. OPERATIONS AND MAINTENANCE MANUALS

A. The Contractor shall have prepared six (6) hardcopies and one (1) electronic copy of the Operations and Maintenance Manuals and deliver these copies of the booklet to the Owner. The booklet shall be as specified herein. The booklet must be approved and will not be accepted as final until so stamped.

B. The booklet shall be bound in a three ring loose-leaf binder similar to National No. 3881 with the following title lettered on the front: Operations and Maintenance Manuals – Smyrna School District – Sunnyside Intermediate School - HVAC. No sheets larger than 8-1/2 inches x 11 inches shall be used, except sheets that are neatly folded to 8-1/2 inches x 11 inches and used as a pull-out. Provide divider tabs and table of contents for organizing and separating information.

C. Electronic copies of the manual shall be saved on USB flash drives, and shall be in searchable PDF format with interactive index tabs. Approved electronic copies shall be stored in flash drive zipper cases in front of Volume 1 (if applicable) of hard copies of the manual.

D. Provide the following data in the booklet:

1. As first entry, an approved letter indicating the starting/ending time of Contractor’s warranty period.
2. Maintenance operation and lubrication instructions on each piece of equipment furnished.
3. Complete catalog data on each piece of heating and air conditioning equipment furnished including approved shop drawing.
4. Manufacturer's extended limited warranties on equipment including but not limited to variable frequency drives, air conditioning compressors, storage tanks, heat pumps, and geothermal exterior piping.
5. Chart form indicating frequency and type of routine maintenance for all mechanical equipment. The chart shall also indicate model number of equipment, location and service.
6. Provide sales and authorized service representatives names, address, and phone numbers of all equipment and subcontractors.
7. Provide supplier and subcontractor’s names, address, and phone number.
8. Catalog data of all equipment, valves, etc. shall include wiring diagrams, parts list and assembly drawing.
9. Provide and install in locations as directed by the Owner, valve charts including valve tag number, valve type, valve model number, valve manufacturer, style, service and location. Each valve chart shall be enclosed in a durable polymer based frame with a cover safety glass.
10. Copy of the approved balancing report including duct leakage data.
11. ATC systems including as-built ATC drawings of systems including internal of all panels.
12. Access panel charts with index illustrating the location and purpose of access panels.
13. Approved Health Department, HVAC Inspector, and Electrical Inspector Certificates.
14. Start-up reports for equipment.
15. Water treatment test reports.
16. Provide and install in locations as directed by Owner, filter charts, including filter type, size, model number, manufacturer, quantity and size for each filter utilized on the project. Filter charts shall be enclosed in a durable polymer based frame with a cover safety glass.
17. Insert color graphic with embedded parameters for ATC system into record and information booklet.
18. Filter charts indicating equipment served, size, and type of filter required.
19. Documentation of strainer pulling and cleaning.
20. Letter stating final concentration of glycol in hydronic systems.
21. Base mounted pump shaft alignment test results.

E. Electronic copies of the manual shall be saved on USB flash drives, and shall be in searchable PDF format with interactive index tabs. Approved electronic copies shall be stored in flash drive zipper cases in front of volume 1 (if applicable) of hard copies of the manual.

F. Submit Record and Information Booklets prior to anticipated date of substantial completion for Engineer review and approval. Substantial completion requires that Record and Information booklets be reviewed and approved.

3.16. INSTALLATION AND COORDINATION DRAWINGS

A. Prepare, submit, and use composite installation and coordination drawings to assure proper coordination and installation of work. Drawings shall include, but not be limited, to the following:

1. Complete Ductwork, Plumbing, Sprinkler and HVAC Piping Drawings showing coordination with lights, electrical equipment, HVAC equipment and structural amenities.

B. Draw plans to a scale not less than 3/8-inch equals one foot. Include plans, sections, and elevations of proposed work, showing all equipment, piping and ductwork in areas involved. Fully dimension all work including lighting fixtures, conduits, pullboxes, panelboards, and other electrical work, walls, doors, ceilings, columns, beams, joists and other architectural and structural work.

C. Identify all equipment and devices on wiring diagrams and schematics. Where field connections are shown to factory-wired terminals, include manufacturer's literature showing internal wiring.

D. Refer to Division 01 Section “Project Management and Coordination” for additional requirements related to coordination drawings.

3.17. PIPING SYSTEMS TESTING

A. The entire new HVAC piping systems shall be tested hydrostatically before insulation covering is applied and proven tight under the following gauge pressures for a duration of twenty-four (24) hours. Testing to be witnessed by Owner's representative and documented in writing.

SYSTEM	**TEST PRESSURE**
Dual Temp Supply & Return Piping Including Chemical Treatment Piping	100 psig
Geothermal Interior Heat Pump Piping, Including Chemical Treatment Piping	100 psig
Geothermal Exterior Heat Pump Piping	See Division 02
Refrigerant Piping	600 psig with Nitrogen

B. Ductwork pressure testing shall be as specified in another division of these specifications.

C. Testing and acceptance thereof shall be in accordance with local requirements and shall meet approval of authority having jurisdiction. Submit certificates and approved permits and insert one (1) copy in the Operations and Maintenance Manuals.

D. Refrigerant piping shall be tested utilizing nitrogen per equipment manufacturer’s requirements.

E. All testing shall be witnessed by Construction Manager.

F. All refrigerant piping shall be installed and tested per <u>ASHRAE 15-Safety Standard for Refrigerant Systems</u>.

3.18. EQUIPMENT BY OTHERS

A. This Contractor shall make all system connections required to equipment furnished and installed under other divisions or furnished by the Owner. Connections shall be complete in all respects to render this equipment functional to its fullest intent.

B. It shall be the responsibility of the supplier of this equipment to furnish complete instructions for connections. Failure to do so will not relieve this contractor of any responsibility for improper equipment operation.

3.19. ADDITIONAL FILTERS AND BELTS

A. One complete set of additional filters and belts shall be turned over to the owner upon final acceptance of the building by the owner. Provide correspondence to the Engineer (copy) documenting that additional filters and belts have been turned over to Owner.

B. All filters and belts shall be tagged and identified for equipment served. Furnish filters in protection wrap.

C. Provide spare set of bag filters for the geothermal fluid filter housing.

3.20. STRAINER CLEANING

A. All equipment strainers must be pulled and cleaned at substantial completion. Document in writing and via digital photographs that all strainers have been pulled and cleaned.

B. One year after project substantial completion all strainers shall be pulled again and cleaned. Document in writing and via digital photographs that all strainers were pulled and clean at the one year after project substantial completion data.

C. Insert documentation that the strainers have been pulled and cleaned in the Record and Information Books.

D. Re-purge hydronic systems of all air after strainers are pulled and cleaned.

END OF SECTION

DIVISION 23 SECTION 23 05 05
HVAC PIPING, FITTINGS & VALVES
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SECTION 23 05 05 - HVAC PIPING, FITTINGS AND VALVES

PART 1. GENERAL

1.1. SUMMARY

A. The conditions of the contract and other general requirements apply to the work specified in this section. All work under this section shall also be subject to the requirements of Division 23 Section, Common Work Results for HVAC and Division 01, General Requirements.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SYSTEM DESCRIPTION CONDITIONS

A. Provide all labor and materials necessary to furnish and install all piping systems on this project as herein specified and/or shown on the drawings. Final connections to equipment furnished in other sections of the specifications shall be included under this section.

B. All piping and insulation installed in ceiling plenums must be plenum rated and comply with NFPA and International Building Code (IBC).

C. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

D. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.

E. Use non-conducting dielectric connections whenever jointing dissimilar metals in open systems.

F. Provide pipe hangers and supports in accordance with ASTM B31.9 and MSS SP69 unless indicated otherwise.

G. Use spring loaded "silent" check valves on discharge of all pumps.

H. Use 3/4 inch (20 mm) ball valves with cap and chain for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest floor drain.

I. At all runout piping serving equipment, use swing joints with elbows to prevent excessive movement of piping due to expansion.

1.3. QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body.

B. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulation. Provide certificate of compliance from authority having jurisdiction indicating approval of welders.

C. Welders Certification: In accordance with ASME Section 9.

D. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

1. All castings used for coupling housings, fittings, and valve bodies shall be date stamped for quality assurance and traceability.

E. Maintain one copy of each document on site.

1.4. DELIVERY, STORAGE AND HANDLING

A. Deliver, store, protect and handle products to site under as hereinbefore specified.

B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

C. Provide temporary protective coating on cast iron and steel valves.

D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed systems.

1.5. ENVIRONMENTAL REQUIREMENTS

A. Do not install underground piping when bedding is wet or frozen.

1.6. EXTRA MATERIALS

A. Provide one (1) repacking kit for each size valve.

1.7. ALTERNATES

A. Refer to Division 01 Section, “Alternates” for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. PIPE MATERIALS

A. All materials, unless otherwise specified, shall be new and of the best quality of their respective kinds, and shall conform to the requirements and ordinances of local, state and insurance authorities having jurisdiction.

1. Direct Buried Exterior Geothermal Energy Recovery Piping:

Refer to Division 23 Section, Ground Loop Heat Pump Piping.

2. Interior Geothermal Water Source Heat Pump Supply & Return Piping, Chemical Treatment Piping, Dual Temperature Supply & Return Piping, Glycol Piping:

   a. Manufactures: Victaulic, Grinnell, or Sure-Joint.
   b. Pipe: Schedule 40 Black steel pipe, ASTM A53 1-1/2 inch and smaller - Type F, ASTM A53 steel (CW) with threaded joints.
      2 inch and larger - Grade B, Type E, ASTM A53 steel (ERW) with welded, flanged or grooved joints.
   c. Fittings & Joints: 2-1/2 inches & larger, schedule 40 wrought steel ASTM A234 Grade WPB or Std. B16.9 long radius welding; factory-fabricated from ASTM A53 pipe; or ASTM A536 ductile iron 2-inches & smaller 125 lb. std. cast iron screwed, ASTM Standard B16.4; or Vic-Press precision, cold drawn, stainless steel with elastomer O-ring seals. Joints shall be threaded or AWS D1.1 welded. Victaulic, Apollo/Shurjoint, or approved equal grooved joints shall also be acceptable.
   d. Flanges: Wrought steel Class 150 welding neck. ASTM Standard B16.5.
   e. Grooved: Joint Couplings: Two ductile iron housings, pressure responsive elastomer gasket, and ASTM A449 zinc electroplated steel bolts and nuts. Couplings shall comply with ASTM F1476 Standard Specification for the Performance of Gasketed Mechanical Couplings for Use in Piping Applications.

      i. Rigid Type: Coupling housings shall be cast with offsetting, angle-pattern bolt pads to provide joint rigidity and support and hanging in accordance with ANSI B31.1 and B31.9.
         1) Victaulic Style 107H, Installation-Ready, Apollo/Shurjoint Z-07N, or approved equal, for direct stab installation without field disassembly, with grade EHP gasket, suitable for water service to +250 deg F.

      ii. Flexible Type: For use in locations where vibration attenuation and stress relief are required, and for the elimination of flexible connectors. Victaulic Installation-Ready Style 177 or Style 77, Apollo/Shurjoint, or approved equal.
      iii. 14” and Larger: AGS Series, two segment coupling with lead-in chamfer on housing key and wide width FlushSeal gasket. Victaulic Style W07 (rigid) and Style W77 (flexible), Apollo/Shurjoint 7707N, or approved equal.
      iv. Flange adapters shall be suitable for direct connection to ANSI Class 125 or 150 flanged components. Victaulic Style 741/W741, Apollo/Shurjoint 65FH, or approved equal.
      v. Ductile iron. Rolled form grooves only. Cut grooves are prohibited.
      vi. Verify gasket compatibility on Chemical Treatment piping.

   f. Gate Valves: 4 inches & larger - IBBM, 150 lb. OS&Y grooved end or flanged; 2 inch & smaller - 150 lb. Bronze body bronze trim. Victaulic Series 771V or approved equal.
      For valves 4 inch and larger located in mechanical equipment spaces 10'-

0-inches or greater above finished floor, valve shall have chain wheel operators with chains extending to within 6 feet –0 inches above finished floor. Chain wheels and guides shall be galvanized.

g. Ball Valves: Shut-off valves 3 inch and smaller shall be ball valves. Ball valves shall be 150 lbs, brass or bronze body, standard port, 2 piece body, TFE seats with bronze trim. Ball valves shall be Vic-Press end, threaded end or solder end as required to accommodate piping. Ball valves shall be as manufactured by Victaulic, Crane, Apollo, Nibco, Watts or engineer approved equal.

h. Globe Valves: 2-1/2 inches & larger - IBBM, 125 lb.std. flanged, with No. 1 disc; 2 inch & smaller - bronze 150 lb.std. screw ends, with #1 disc.

i. Check Valves: 2-1/2 inches & larger – IBBM or stainless steel trim, 125 lb.std. grooved end or flanged spring-assisted swing check suitable for vertical or horizontal installation, with metal disc; 2 inch & smaller - 125 lb. std. screwed. Provide "silent" spring loaded check valves at all pump discharges. Victaulic Series 716/W715, Apollo/Shurjoint 67CVE/CVN, or approved equal.

j. Balancing Valves: Victaulic Series 377/365, DeZurik Series 100, Fig. 118, Milliken, or engineer approved equal, ductile iron or cast iron construction, stainless steel bearings, nickel seats (3 inches and larger) non-lubricated, eccentric plug with EPDM or chlorobutyl rubber or Bunz-N resilient faced plugs suitable for 230 degrees Fahrenheit, semi-steel screwed with fig. 159, removable lever and open. nut for valves 3 inches and smaller. For valves 4 inches and larger, provide gear operators and grooved ends or flanged connections. Provide chain operated valves for sizes 4 inches and larger located 10 feet –0 inch or more above finished floor. Chains shall extend to within 6 feet –0 inch above finished floor. All valves shall have adjustable memory stop. Chain wheel and guide shall be galvanized. Do not install balance valves on the discharge of variable speed pumps.

k. Butterfly Valves: Victaulic Vic300 MasterSeal/ AGS – Vic300, DeZurik, Apollo/Shurjoint SJ-300-N, high performance, Milwaukee HP Valve, or Keystone K-Loc, type with infinite position lever (for 4 inches and larger) and pressure responsive seat or double seat type and memory stop. Provide gear operator on valves 4-inches and larger. For valves 4 inches and larger located 10 feet –0 inch or more above finished floor shall be provided with chain operators with chains extending to within 6'-0-inches above finished floor. Chain wheel and guide shall be galvanized.

    i. Valve stem shall be stainless steel, and shall be offset from the disc centerline to provide complete 360 degree circumferential seating.
    ii. Valve shall be rated to +250 deg F in sizes through 12 inches.
    iii. Seat shall be elastomer, of a grade suitable for the intended service. The seat shall be pressure responsive in sizes through 12 inches.

l. Combination Shut-off/Balancing Valves:
Victaulic/ TA Hydronics, Taco Circuit Setter, Bell & Gossett Circuit Setter Plus, Flowset Accuset, Gerand, or as approved equal, 2 inches- 3 inches 300 lb. rated Ametal (copper-alloy) body globe type or ball valve

with bronze body/brass ball construction with glass and carbon filled TFE seats, in-line flow meter and balancing and shut-off valve with built in ball valve for flow adjustment. Valve shall have memory stop, calibrated nameplate, Schrader valve connections and preformed molded insulation. Valves shall be leaktight at full rated working pressure. Balance valve size shall be selected based on manufacturer's acceptable flow range and design flow rate. Pressure drop through combination shut off balance valves shall not exceed 5 feet of head at design flow rate. The meter to remain with the owner after commissioning. Where required for flow rates below 0.6 GPM, provide "reduced flow" combination shut-off balance valves sized so that the flow rate is within the manufacturer's recommended flow range.

Coil-Hook-up Connections: Victaulic Koil-Kits Series 799 or 79V or approved equal may be used at coil connections. The kit shall include a autoflow balancing valve, Series 78Y Strainer-Ball, Series 78U Union-Port fitting, with Series 78T ball valve and required coil hoses. A Style 793 and/or 794 differential pressure controller shall be provided as required.

m. Extended Valve Stems: Provide and install round collar type extended valve stems on all valves installed in insulated piping. Valve stem and collar shall be selected to suit insulation thickness and maintain valve handles outside of insulation.

n. Alternate:

   i. At contractors option, all interior water source heat pump and dual temperature supply and return lines may be copper type L (ASTM Std. B88) with wrought copper fittings (ASTM Std. B 16.22) with brazed or 95-5 silver solder joints lead and antimony based solders are prohibited and all bronze valves may be used on piping 2-inches and less in size.

   ii. At Contractors option, copper press fittings may be utilized. Copper press fittings manufactured by ProPress, Viega, Apollo Press/Apollo Power Press, and Mueller Streamline Co. are acceptable for Pressure Seal Fittings: Bronze or copper shall conform to ASME B16.51, ICC LC 1002, and IAPMO PS 117. ProPress fittings ½-inch thru 4- inch for use with ASTM B88 copper tube type L and ½-inch up to 1-1/4-inch annealed copper tube. ProPress fittings shall have an EPDM sealing element and Smart Connect (SC) feature. 2-1/2-inch thru 4-inch shall have a 420 stainless steel grip ring, PBT separator ring, EPDM sealing element and Leak detection feature.

   iii. At the Contractor's option, interior geothermal and dual temperature piping may be Isco, Aquatherm, NiRon, or Pestan polypropylene pipe and fittings. Pipe shall contain a fiber layer (faser) to restrict thermal expansion. Furnish pipe with factory applied UV resistant coating. All joints shall be fusion welded per manufacturer's requirements. Install expansion loops as required by the manufacturer. Where installed in plenums install fire resistant wrap on all piping to comply with NFPA.

3. Refrigeration Piping:

a. Concealed: Tube Size ¾ -inch & Smaller:
ASTM B280, copper tube; Type ACR, soft annealed temper fittings; cast copper-alloy fittings for flared copper tubes; flared joints. Fittings shall be ASME B16.22, wrought copper. Joints shall be brazed, AWS A5.8, BCUP silver/phosphorous/copper alloy with melting range 1190 to 1480 degrees F.

b. Concealed: Tube Size 7/8 inch through 4-1/8inches:
Copper tube, Type ACR, soft annealed temper; wrought-copper, brazed-joint fittings; brazed joints.

c. Exposed: Tube Size ¾ Inch and Smaller:
Copper pipe, Type ASTM B88, Type K with brazed wrought-copper fittings conforming to ASME B16.22. Filler metal shall be brazing type conform to AWS A5.8.

d. Exposed: Tube Sizes 7/8 Inch and Larger:
Copper pipe, Type ASTM B88, Type K with brazed wrought-copper fittings conforming to ASME B16-22. Filler metal shall be brazing type conforming to AWS A5.8.

e. Brazed Joints: Braze joints using American Welding Society (AWS) classification BCuP-4 for brazing filler metal.

f. Flexible connectors: 500-psig (3450-kPa) minimum operating pressure; stainless-steel core and high-tensile stainless-steel-braid covering; dehydrated, pressure tested, minimum 7 inches (180 mm) long.

g. Diaphragm Packless Valves:
500-psig (3450-kPa) working pressure and 275 degrees Fahrenheit (135 degrees C) working temperature; globe design with straight-through or angle pattern; forged-brass or bronze body and bonnet, phosphor bronze and stainless-steel diaphragms, rising stem and handwheel, stainless-steel spring, nylon seat disc, and with solder-end connections.

h. Packed-Angle Valves: 500-psig (3450-kPa) working pressure and 275 degrees Fahrenheit (135 degrees C) working temperature; forged-brass or bronze body, forged-brass seal caps with copper gasket, back seating, rising stem and seat, molded stem packing, and with solder-end connections.

i. Check Valves: Smaller than NPS 1 (DN 25): 400-psig (2760-kPa) operating pressure and 285 degrees Fahrenheit (141 deg Celsius) operating temperature; cast-brass body, with removable piston, polytetrafluoroethylene seat, and stainless-steel spring; globe design. Valve shall be straight-through pattern, with brazed-end connections.

j. Check Valves: NPS 1 (DN 25) and Larger: 400-psig (2760-kPa) operating pressure and 285 degrees Fahrenheit (141 deg Celsius) operating temperature; cast-bronze body, with cast-bronze or forged-brass bolted bonnet; floating piston with mechanically retained polytetrafluoroethylene seat disc. Valve shall be straight-through or angle pattern, with solder-end connections.

k. Service Valves: 500-psig (3450-kPa) pressure rating; forged-brass body with copper stubs, brass caps, removable valve core, integral ball check valve, and with brazed-end connections.

l. Solenoid Valves: Comply with ARI 760; 250 deg Fahrenheit (121 deg Celsius) temperature rating and 400-psig (2760-kPa) working pressure; forged brass, with polytetrafluoroethylene valve seat, 2-way, straight-through pattern, and brazed-end connections; manual operator; fitted with suitable NEMA 250 enclosure of type required by location, with 1/2-inch (16-GRC) conduit adapter and 24-V, normally closed holding coil.

m. Pressure-Regulating Valves:
Comply with ARI 770; pilot operated, forged brass or cast bronze, stainless-steel bottom spring, pressure-gage tapings, 24-V dc standard coil, and wrought-copper fittings for brazed-end connections; suitable for refrigerant specified.

n. Pressure Relief Valves: Straight-through or angle pattern, brass body and disc, neoprene seat, and factory sealed and ASME labeled for standard pressure setting.

4. Cooling Coil A/C Condensate Drain and Floor Drain Piping that is Collecting A/C Condensate Piping:

a. Pipe & Fittings: All A/C condensate drain piping, including floor drain piping that is collecting A/C condensate, shall be constructed of Type L copper tubing, with sweat fittings made with 95-5 solder. Washout plugs (cleanouts) shall be strategically located to allow periodic flush out of system. At a minimum, provide washout plugs at equipment connections and at direction changes of 90 degrees F or greater. Also install cleanout at all equipment traps for cleaning and service.

b. Provide backwater valve (ball float type) at connections of condensate piping to stormwater piping and air gap fitting. Backwater valve shall be Model Z1099 as manufactured by Zurn or approved equal. Backwater valve shall have drain coated cast iron body, plastic ball float, bronze backwater bushing and replaceable neoprene seat.

c. Exterior condensate pipe penetrations must exit exterior wall above flashing. Extend discharge away from exterior walls as detailed.

5. Dishwasher Condensate Hood Piping:

a. Pipe & Fittings: All dishwasher condensate hood drain piping shall be constructed of schedule 40 stainless steel piping with threaded joints. Washout plugs (cleanouts) shall be strategically located to allow periodic flush out of system. At a minimum, provide washout plugs at equipment connections and at direction changes of 90 degrees Fahrenheit of greater.

b. Prime and paint exposed dishwasher condensate hood drain piping in color as selected by Architect.

B. Steel pipe shall be similar and equal to National Tube Company, Grinnell, Republic, or Bethlehem black or zinc-coated (galvanized) as hereinafter specified. Pipe shall be free from all defects which may affect the durability for the intended use. Each length of pipe shall be stamped with the manufacturer's name.

C. Copper pipe shall be Revere, Anaconda or Chase with approved solder fittings.

D. Welding fittings for steel pipe shall meet the requirements of ASTM Standard A-23 and shall be standard catalog products. Fittings fabricated by metering and notching pipe will not be accepted.

2.2. PIPE HANGERS, ROLLER SUPPORTS, ANCHORS, GUIDES, AND SADDLES

A. All hangers for metallic piping shall be adjustable, wrought clevis type, or adjustable malleable split ring swivel type, having rods with machine threads. Hangers shall be Grinnell Company's Figure 260, Victaulic, or Shurjoint for pipe ¾-inch and larger, and Figure 65 for pipe 2-inches and smaller, or approved equal Victaulic, Shurjoint, Carpenter Patterson, or approved equal. Adjustable pipe stanchion with U-bolt shall be Grinnell Company's Figure 191. Pipe roller supports shall be Grinnell's Figure 181 or Figure 271 Victaulic or Shurjoint. Exterior pipe hangers shall be galvanized or stainless steel construction. For copper piping in direct contact with the hanger, hanger construction shall be copper coated to prevent contact of dissimilar metals similar to Grinnell's Figure CT-65. Hanger spacing and rod sizes for steel and copper pipe shall not be less than the following:

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
3/4 & 1	6	5	3/8
1 - ½	6	8	3/8
2	8	8	3/8
2 – ½	10	9	½
3	12	10	½
4	14	12	5/8

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
5	14	12	5/8
6	16	14	3/4
8	18	16	7/8
10	20	18	7/8
12	20	18	7/8

B. Anchors, guides, and roller supports shall be installed in accordance with the contract drawings and manufacturer's recommendations to provide pipe support and control pipe movement for all piping systems. Anchors and guides shall be securely attached to the pipe support structure. Submit shop drawing for proposed pipe support structure for guides and anchors for approval of the Structural Engineer. Pipe alignment guides shall be Fig. 255 Grinnell, or as approved equal. Guides shall be sized to accommodate the pipe with insulation. Guides shall be steel factory, fabricated, with bolted two section outer cylinder and base for alignment of piping and two section guiding spider for bolting to pipe.

C. Hangers for pipe sizes ½ to 1 ½ inch (13 to 38 mm): Carbon steel, adjustable swivel, split ring.

D. Hangers for cold pipe sizes 2 inches (50 mm) and over: Carbon steel, adjustable, clevis.

E. Hangers for cold pipe sizes 2 to 4 inches (50 to 100 mm): Carbon steel, adjustable, clevis.

F. Hangers for cold pipe sizes 6 inches (150 mm) and over: adjustable steel yoke, cast iron roll, double hanger.

G. Multiple or Trapeze hangers: Steel channels with welded spacers and hanger rods.

H. Multiple or Trapeze hangers for hot pipe sizes 6 inches (150 mm) and over: Steel channels with welded spacers and hanger rod, cast iron roll.

I. Wall support for pipe sizes to 3 inches (76 mm): cast iron hook

J. Wall support for pipe sizes 4 inches (100 mm) and over: Welded steel bracket and wrought steel clamp.

K. Wall support for hot pipe sizes 6 inches (150 mm) and over: welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.

L. Vertical Support: Steel riser clamp.

M. Floor support for cold pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

N. Floor support for hot pipe sizes to 4 inches (100 mm): Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

O. Floor support for hot pipe sizes 6 inches (150 mm) and over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.

P. Copper pipe support: Carbon steel ring, adjustable, copper plated.

Q. Hanger rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

R. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

S. For exterior pipe supports provide stainless steel, supports, brackets, hardware and anchors.

T. For pipe hangers installed in corrosive environments such as chemical storage rooms the same shall (including hardware) shall be finished with on Electro-Galvanized Finish such as Galv-Krom® or approved equal.

2.3. HYDRONIC BELLOW EXPANSION JOINTS

A. Metal expansion joints shall consist of a single hydraulically formed metal bellows with flange end fittings. Flanges shall be carbon steel and ANSI B16.5 150# type. The bellows shall be 316 stainless steel.

B. Joints shall be designed to meet the design pressures and temperature for the system, and shall be capable of accommodating piping system and equipment movements as needed.

C. Tie rods shall be included to prevent overextension of the expansion joints from pressure thrust loads. The number and size of the control rods shall be sufficient for the maximum system test pressure.

D. Expansion joints shall be Flexicraft Industries Model NLC, MetraFlex, Thunder Technologies, or approved equal.

2.4. VALVES

A. Provide parts list and assembly drawings (exploded view) for all valves in shop drawing submittals. Provide valves of the same type by the same manufacturer.

B. Check valves in base mounted pump discharges shall be of the vertical type and shall be Victaulic Series 716/ W715, Miller "non-slam" check valves, Apollo, Shurjoint SJ-900, Grinnell, or approved equal suitable for service intended. Check valves in circulator discharges shall be horizontal type.

C. Provide at each base mounted pump a suction diffuser of size and type shown on drawings. Units shall consist of a ductile cast iron angle type body with inlet vanes, magnetic insert, and blowdown connection tapped gauge post, 125 psi ANSI flange and a combination stainless steel diffuser strainer with 5/32 or 3/16-inch diameter opening for pump protection. Unit shall be equipped with a disposable fine 20-mesh stainless steel start up strainer which shall be removable after 30 days. Flow direction shall be from inside the strainer to outside for ease of service and cleaning. The body shall fit the pump and connecting pipe size. The unit shall be provided with a base support boss or an adjustable support foot to relieve piping strains from the pump suction. Suction diffuser shall be Victaulic 731 Series, Taco "SD" Series Catalog 300-4.1, Bell and Gossett Model FLG, Armstrong, Patterson, Apollo/Shurjoint 725F, or engineer approved equal.

D. Multi-purpose valve (non-slam check valve, throttling valve, shut-off valves and calibrated balancing valve) shall be provided at discharge side of constant speed pumps. The valve shall be of heavy-duty cast iron construction with standard ANSI flanged connections and rated for a maximum working pressure of 175 psig at 240°F. The valve shall be fitted with a stainless steel stem or stem sleeve and brass seat with "O" ring seal. Valve shall be Taco "Plus One" Number 300-4.2, Bell and Gossett 3DS Triple Duty Valve, Armstrong, Patterson, or as approved equal, and shall have check and plug valve features plus a memory stop with pointer and scale. Provide additional shut-off valve to allow servicing of check valve if a multipurpose valve is utilized in lieu of separate check, shut-off, and balance valve. Provide additional shut-off valve downstream of multi-purpose valve to allow servicing of multi-purpose check valve feature. Provide pre-manufactured, removable insulation covers for all multipurpose valves.

E. Triple Duty Valve Assembly: Assembly shall consist of a Victaulic Master Seal, Apollo/Shurjoint SJ-900, Grinnell, or approved equal butterfly valve with memory stop and a Series 779 Venturi-Check, rated for water service to 230 degrees Fahrenheit (110 degrees Celsius) and pressures to 300 psig (2065-kPa).

1. For 14” through 24” sizes, Victaulic AGS-Vic300, Apollo/Shurjoint SJ-300N-L/SJ-300N-W, Grinnell, or approved equal butterfly valve with Series W715 AGS check valve, rated for pressures to 230 psig (1575-kPa).

F. Do not install multipurpose valves or balance valves on the discharge of variable speed pumps.

2.5. AUTOMATIC FLOW CONTROL VALVES

A. Automatic flow control valves shall be provided and installed where indicated. Units shall be factory set to maintain constant flow with plus or minus 5 percent over system pressure fluctuations, and equipped with a readout kit including flow meter, probes, hoses, flow charts, and carrying case. Each valve shall have an identification tag attached by chain and be factory marked with the zone identification, valve number and flow rate. Valves shall be line size and shall be Model AC or WU as manufactured by Flow Design, Inc., Victaulic Series 76, Griswald Controls, Bell & Gossett, or approved equal.

B. Valves shall be selected for 2 - 32 psig flow range. Furnish valves with extended valve handle, stem extender, ball valve, flow regulator and unions. Where velocities are below 2 feet per second utilize 5-60 psig auto flow valves to avoid noise issues. 5-60 psig autoflow valves must be utilized where gpm is less than 2.0 gpm for ½ inch or ¾" autoflow valves.

C. Design:

1. The GPM for the automatic flow control valves shall be factory set and shall automatically limit the rate of flow to within 5% of the specified GPM over at least 95 percent of the control range.
2. For ½ -inch – 2-inches, the flow cartridge shall be removable from the Y-body housing without the use of special tools to provide access for regulator change-out, inspection and cleaning without breaking the main piping. (Access shall be similar to that provided for removal of a Y-strainer screen).
3. Pump Head Requirements: the permanent pressure loss added to the pump head shall not exceed seven feet.
4. Each valve shall have two P/T ports.
5. All automatic flow control devices shall be supplied by a single source and certified flow tests, witnessed by a professional engineer, shall be available.
6. Five-year product warranty and free first-year cartridge exchange, up to 10 percent.

D. Construction:

1. The internal wear surfaces of the valve cartridge shall be stainless steel.
2. The internal flow cartridge body shall have machined threads so the spring free height may be compensated for without the use of fixed shims. A crimped sheet metal design is not acceptable.
3. The internal flow cartridge shall be permanently marked with the GPM and spring range.
4. For ½-inch through 2-inch pipe sizes: An assembly shall consist of a brass Y-type body, integral brass-body ball valve and "O" ring type union; Flow Design Model AC or approved equal.
5. For 2½-inches and larger flanged connections: Ductile-iron body suitable for mounting wafer style between standard 150# or 300# flanges. The long flange bolts and nuts shall be provided with each control valve. Flow Design Model WS or approved equal.
6. All valves shall be factory leak tested at 100 psig air under water.

E. Minimum ratings:

1. ½-inch through 2-inch pipe size: 400 PSIG at 250 degrees Fahrenheit.
2. 2 ½ -inch through 14-inch pipe size: 600 PSIG at 250 degrees Fahrenheit.
3. 16-inch through 30 -inch pipe size: 250 PSIG at 250 degrees Fahrenheit.

F. Flow Verification

1. The differential pressure across the Automatic Flow Control Valve shall be measured for flow verification and to determine the amount of system over heading or under pumping.

2.6. STRAINERS

A. Strainers shall be of the basket or "Y" type and shall be heavy and durable, constructed of ductile iron to ASTM A536 or the best grade gray iron with the bottoms drilled and plugged. Bodies shall have arrows clearly cast on the sides to show flow direction. Strainers shall be equipped with easily removable covers and brass sediment baskets made of stainless steel or brass not less than #22 gauge in thickness. Total area of basket perforations shall be not less than four times the cross section of the entering pipe. Flow shall be into basket, and then out through the perforations. Strainers shall be suitable for water or the intended fluid. Strainers 2 inches and smaller shall have threaded or solder ends, 2 inches and larger shall have flanged ends.

B. Strainer screens shall be stainless steel with perforations and shall be 1/16-inch for pipe sizes 5 inches and less, 1/8-inch (40 percent open area) perforations for pipe sizes 6-inch and greater.

C. Provide valved and capped (with chain) blowdowns in each strainer. Blowdown valves shall be Apollo 78-100/200 series or as approved equal.

D. Strainers shall be manufactured by Victaulic Style 732/W732, Watts, Mueller, Armstrong, Yarway, Spirax/Sarco, Apollo/Shurjoint 726, or as approved equal.

2.7. UNIONS, FLANGES, AND COUPLINGS

A. Unions in steel pipe 2-inches and smaller shall be malleable iron with brass inserted seats designed for a working pressure of 150 psig.

B. Unions in copper pipe 2-inches and smaller shall be sweat fittings with bronze seats designed for a working pressure of 125 psig.

C. Unions in stainless steel pipe 2-inches and smaller shall be hexagonal threaded type stainless steel unions, with VicPress ends. Basis of Design: Victaulic Style P584.

D. Flanges for steel pipe over 2 inches shall be 150 psig, forged steel, slip on. Gaskets shall be 1/16 inch thick pre-formed neoprene.

E. Flanges for copper pipe over 2 inches shall be bronze. Gaskets shall be 1/16 inch thick preformed neoprene.

2.8. MANUAL AIR VENTS

A. Manual air vents shall be similar to the hereinafter specified gauge valves. Provide 1/4-inch size on ¾-inch pipe and smaller, ½ -inch size on 1-inch pipe and larger. Install at all high points of piping. Valves shall be Crane No. 88, or as approved equal, with threaded ends, bronze body, bronze or brass bonnet and bronze stem.

2.9. AUTOMATIC AIR VENTS

A. Provide at air separators, expansion tanks and where shown on the drawings, float actuated non-modulating high capacity air vent to purge free air from the system and provide a positive shut-off at pressures up to 150 psig at a maximum temperature of 250 degrees Fahrenheit. The high capacity air vent shall prevent air from entering the system if the system pressure drops below atmospheric pressure. The air vent shall be pilot operated for intermittent purging of free air up to pressures of 2 psig during normal system operation and diaphragm operated for full capacity purging of free air at pressures between 2 and 150 psig. The high capacity air vent shall be constructed of cast iron and fitted with components of type 313 stainless steel, brass, EPDM and silicone rubber. Pipe discharge to closest floor drains with Type K copper tubing. The high capacity vent shall be Model 107 by Bell and Gossett, Model 13w by Spirax Sarco, Taco, Spirotherm Spirotop, or as approved equal.

2.10. THERMOMETERS

A. Unless otherwise indicated, thermometers shall be ASTM E1, in a glass type, organic filled, 9-inch scale size, corrosion-resistant metal case, with "any-angle" mounting with positive locking device. Trerice Industrial Thermometers, Weksler Instruments, Ernst Gage Co., Miljoco, or approved equal. Insertion stem length shall suite the pipe size and configuration. Thermometer wells shall be brass with brass union hubs in copper and in ferrous piping. Where piping is insulated or otherwise covered, use wells with lagging extension. Where wells are installed in pipe tees at turns, increase pipe size so that well does not restrict flow. Accuracy shall be 2 percent.

B. Unless otherwise indicated, thermometer ranges shall be as follows:

1. Geothermal systems: 0 degrees F to 100 degrees Fahrenheit, 1 degrees Fahrenheit Division
2. Dual Temperature: 30 degrees Fahrenheit to 240 degrees Fahrenheit, 2 degrees Fahrenheit Division.

C. Provide heat conducting compound in wells.

2.11. PRESSURE GAUGES

A. Unless otherwise indicated, pressure gauges shall be the bronze bourdon tube type, 4-1/2-inch dial, stem mounting, cast aluminum adjustable pointer, 1 percent accuracy over middle half of scale range, 1-1/2 percent over balance: Trerice Model 600C; Weksler Instruments, Ernst Gage Co., Miljoco, or as approved equal.

B. Gauges shall have pressure, vacuum, compound, or retard ranges as required, select ranges so that the normal readings are at the approximate midpoint and maximum system pressures do not exceed full scale.

C. Furnish and install a gauge valve at each pressure gauge. Gauge valves shall be Crane Model No. 88, Needle Valve, Ernst Gage Co. FLG 200, Wexler Instrument Corp. Type BBV4, or approved equal, rated for pressure intended.

D. Gauge connections for pressure gauges, thermometers, or control instruments shall be made using tee fittings, except that gauge connections up to 1-inch size in steel may be using threaded extra heavy pipe couplings welded directly to the main, provided that the main is at least 2-inch size for 2-inch connections, 3-inch size for 3/4-inch connections, and 4-inch size for 1-inch connections. Minimum gauge connection shall be 2-inch ips.

E. Provide snubbers on all gauges. Snubbers shall be No. 872 by Trerice, RS1/RS6 by Wexler Instruments, Miljoco or as approved equal.

2.12. FLOW METER FITTINGS

A. Griswold or Bell & Gossett Venturi disturbed flow measurement quickset flow meter fittings shall be utilized for hydronic flow measurement. Units shall consist of a spun steel venturi welded into the pipe. Disturbed fluid shall be channeled through the throat of the venturi with a multi-point Piezo Ring. Accuracy shall be ± 1% PSID with no straight pipe run required.

2.13. PIPING SPECIALTIES

A. Furnish and install flexible pipe connections, as specified and/or shown on the drawings, at suction and discharge connections of all base mounted and vertical in-line pumps, connections to heat pumps, all vibrating equipment, and elsewhere as shown. Pump flexible connections shall be utilized at pumps and hose kits at heat pumps. Refer to Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment for specifications.

B. Pressure relief valves shall be provided in the number and sizes required to relieve 110 percent of the full input to the systems. Valves shall be rated; and installed in accordance with ASME, and CSD-1 including all amendments. Pipe discharge full size to floor drain, (with union) and support discharge pipe to prevent exerting any strain on relief valve body, piping to be Type-L copper. Water safety relief valves shall be Watts Series 740, Conbraco, Series 154A, Bell and Gossett, or approved equal. Provide pressure gauge adjacent to all safety relief valves.

C. Gas relief valve piping shall be sized and installed in accordance with the latest edition of ASME Boiler & Pressure Vessel Code, CSD-1 including amendments. Pipe material shall be as specified for gas piping. Gas relief valve piping material shall be the same as hereinbefore specified for gas piping.

2.14. ESCUTCHEONS

A. Provide chromium plated escutcheons properly fitted and secured with set screws on all exposed piping which passes through walls, floors or ceilings of finished spaces.

B. All escutcheon plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface. Plastic escutcheon plates will not be accepted.

2.15. DIELECTRIC CONNECTIONS:

A. Furnish and install electrically insulated dielectric waterway fittings, unions or flanges, as manufactured by Victaulic Company Style 47, EPCO Sales, Inc., or approved equal at the following locations:

1. Where steel piping systems join copper piping.
2. Where copper tube connects to buffer tanks, domestic water storage tanks, water heaters, expansion tanks, and other steel vessels.
3. Avoid the installation of steel nipples, cast iron or steel valves and specialties, or other ferrous components in predominately copper piping systems. Where such installation is necessary, isolate the component with dielectric connections. Do not mix steel pipe and copper tube in the same run of pipe or in the same section of a piping system.
4. Dielectric Waterway: Copper silicon casting conforming to UNS C87850 with grooved and/or threaded ends. UL classified in accordance with NSF-61 for potable water service, and shall meet the low-lead requirements of NSF-372. Basis of Design: Victaulic Series 647.

2.16. SLEEVES

A. Sleeves shall be provided around all pipes through walls, floors, ceilings, partitions, roof structure members or other building parts. Sleeves shall be standard weight galvanized iron pipe two sizes larger than the pipe or insulation so that pipe or insulation shall pass through masonry or concrete walls or floors. Provide 20 gauge galvanized steel sheet or galvanized pipe sleeves for all piping passing through frame walls.

B. Sleeves through floors shall be flush with the floor except for sleeves passing through Equipment Rooms which shall extend ¾-inch above the floor. Refer to Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment for mechanical equipment room penetrations additional requirements. Space between the pipe and sleeve shall be caulked. Escutcheon plates shall be constructed to conceal the ends of sleeves. Each trade shall be responsible for drilling existing floors and walls for necessary sleeve holes. Drilling methods and tools shall be as hereinbefore specified.

C. Sleeves through walls and floors shall be sealed with a waterproof caulking compound.

D. Firestop at sleeves that penetrate smoke barriers smoke partitions and/or rated walls/floors.

2.17. PRESSURE REDUCING VALVES

A. Provide pressure reducing valves as indicated, of size and capacity selected by the installer to maintain operating pressure on the system. Body shall be cast-iron or bronze construction, renewable stainless steel seat, non-corrosive disc, water tight cage assembly, adjustable pressure ranges and inlet strainer Watts Regulator Model 223-S, Armstrong, Bell and Gossett, Apollo 36LFPR, or as approved equal.

B. Provide pressure gauge adjacent to all pressure reducing valves to verify proper set point.

2.18. WATER PROOF PIPE PENETRATION SEALS

A. Provide and install waterproof pipe penetration seals at all pipes that enter the building below grade or through exterior wall.

B. Link seals are to be Metraflex Metraseals, Model MS, Linkseal, or approved equal, black EPDM seal material, glass reinforced plastic pressure plates, zinc plated nuts and bolts, seals are to be resistant to sunlight and ozone, pressure rated to make a hydrostatic seal of up to 20 psig and up to 40 feet of head, temperature rated from –40 degrees F to 250 degrees Fahrenheit.

2.19. TEST PLUGS

A. Where indicated, furnish and install P/T plugs or Pete’s Plugs as manufactured by IMAC Systems or approved equal.

B. Description: Nickel-plated, brass-body test plug in NPS 2 (DN15) fitting. Test plugs shall be as manufactured by Trerice, Watts, Natural Meter, Apollo Brass Test Plugs, or approved equal. Test-station fitting made for insertion in piping tee fitting.

C. Body: Length as required to extend beyond insulation. Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS ¼ (DN 8) or NPS ½ (DN15) as required, ASME B1.20.1 pipe thread.

E. Pressure Rating: 500 psig minimum.

F. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

G. Core Inserts: One or two self-sealing valves, suitable for inserting 1/8 inch OD probe from dial-type thermometer or pressure gage. Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

H. Core Insert: Self-sealing valve, suitable for inserting 1/8 inch OD probe from dial-type thermometer or pressure gage.

I. Core Material for Air, Water, Oil, and Gas: 20 to 300 degrees F chlorosulfonated polyethylene synthetic rubber.

J. Test-Plug Cap: Gasketed and threaded cap, with retention chain or strap.

K. Pressure Gage and Thermometer Ranges: approximately two times the system's operating conditions.

L. Self-closing valves with caps and retaining straps.

2.20. FLO-CONTROL VALVES

A. Furnish and install flo-control valves as shown on contract drawings to prevent gravity circulation in forced hot water systems. Flo-control valves shall be Bell & Gossett flo-control valves, TACO flo checks, or approved equal.

B. Flo-control valves shall be suitable for installation in vertical or horizontal piping. Disc shall be precision machined bronze. Valve seats shall be heavy wall brass. Flo-control valves shall be suitable for a maximum operating temperature of 275 degrees F and a maximum working pressure of 125 psig. Flow-control valves shall not be selected based on line size. Select flow-control valves at design flow rate to limit pressure drop to 6 Ft head.

C. Flo-control valves shall be constructed to allow cleaning without breaking pipe connections. Flo-control valves shall be installed with clearances from center line of valves to ceiling as required by manufacturer. Flo-control valves shall feature a manual open position for gravity circulation.

2.21. TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Plastic-to-Metal Transition Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Charlotte Pipe and Foundry Company.
b. Harvel Plastics, Inc.
c. Spears Manufacturing Company.

2. Description: PVC or CPVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert and one solvent-cement-socket end.

D. Plastic-to-Metal Transition Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Colonial Engineering, Inc.
b. NIBCO INC.
c. Spears Manufacturing Company.

2. Description: PVC or CPVC four-part union. Include brass threaded end, solvent-cement-joint plastic end, rubber O-ring, and union nut.

PART 3. EXECUTION

3.1. GENERAL PIPING INSTALLATION REQUIREMENTS

A. All pipes shall be cut accurately to measurements established at the building, and shall be worked into place without springing or forcing, properly clearing all windows, doors and other openings. Excessive cutting or other weakening of the building structure to facilitate piping installation will not be permitted. All pipes shall be so installed as to permit free expansion and contraction without causing damage. All horizontal mains shall pitch down in the direction of flow with a grade of not less than 1 inch in 40 feet. All open ends of pipe lines, equipment, etc., shall be properly capped or plugged during installation to keep dirt or other foreign material out of the system. All pipes shall be run parallel with the lines of the building and as close to walls, columns and ceilings as may be practical, with proper pitch. All piping shall be arranged so as not to interfere with removal of other equipment on devices not to block access to doors, windows, manholes, or other access openings. Flanges or unions, as applicable for the type of piping specified, shall be provided in the piping at connections to all items of equipment, coils, etc., and installed so that there will be no interference with the installation of the equipment, ducts, etc. All valves and specialties shall be placed to permit easy operation and access and all valves shall be regulated, packed and glands adjusted at the completion of the work before final acceptance. All piping shall be installed so as to avoid air or liquid pockets throughout the work. Ends of pipe shall be reamed so as to remove all burrs.

B. All piping shall be graded to convey entrained air to high points where automatic air vents shall be provided. The size of supply and return pipes for each piece of equipment shall in no case be smaller than the outlets in the equipment.

C. All piping shall be run to provide a minimum clearance of 2-inches between finished covering on such piping and all adjacent work. Group piping wherever practical at common elevations.

D. All valves, strainers, caps, and other fittings shall be readily accessible.

E. Drain valves with hose connections shall be provided at low points for drainage of piping systems. Blow down valves shall be provided at the ends of all mains and branches so as to properly clean by blowing down the lines throughout in the direction of normal flow.

F. Discharge lines from all relief valves shall be piped to within 4-inches of floor and extend to floor drains wherever floors are not pitched to drains. Pitch the relief valve piping away from the relief valve to issue that no fluid can be trapped in valve discharge. Support all relief valve piping to prevent exerting strain on the relief valve body. The end of the relief valve discharge piping shall not be threaded to prevent capping or plugging.

G. All branches from water mains shall be taken from the top of the supply mains at an angle of forty-five (45) degrees above the horizontal, unless otherwise directed. Branches feeding down shall be taken from the side or bottom of the main on water mains only. All connections shall be carefully made to insure unrestricted circulation, eliminate air pockets or trapped condensate, and permit the complete drainage of the system.

H. Cutoff valves shall be provided on each branch line from the mains on all heating/air conditioning lines.

I. Shut-off valves shall be installed at the inlet and outlet of each coil and piece of equipment to permit isolation for maintenance and repair. Units having multiple coils shall have separate valves for each coil.

J. Balancing valves shall be installed in all heating/air conditioning water branches and at all pumps, and where indicated on the drawings.

K. Unions shall be installed on all bypasses, ahead of all traps, at all connections to equipment, where shown on drawings or where required to facilitate removal of equipment whether shown or not.

L. Spring clamp plates (escutcheons) shall be provided where pipes are exposed in the building and run through walls, floors, or ceilings. Plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface.

M. If the size of any piping is not clearly evident in the drawings, the Contractor shall request instructions for the Engineer as to the proper sizing. Any changes resulting from the Contractor's failure to request clarification shall be at his expense. Where pipe size discrepancies or conflicts exist in the drawings, the larger pipe size shall govern.

N. Approved expansion loops shall be provided to permit free expansion and contraction of all piping systems.

O. Install all valves with stem upright or horizontal, not inverted.

P. Where pipe support members are welded to structural building framing, scrape, brush clean, weld and apply one coat of zinc rich primer.

Q. Provide clearance for installation of insulation and access to valves and fittings.

R. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

S. All water containing pipes shall be routed clear of combustion air dampers and louvers to prevent freezing condition when dampers are open.

T. Provide manual air vents at top of piping systems.

3.2. THERMOMETER AND PRESSURE GAGE INSTALLATION REQUIREMENTS.

A. Install thermometers and adjust vertical and tilted positions.

B. Install separable sockets in vertical position in piping tees where fixed thermometers are indicated.

1. Install with socket extending to one-third diameter of pipe.
2. Fill sockets with oil or graphite and secure caps.

C. Install pressure gages in piping tees with pressure-gage valve located on a pipe at most readable location.

D. Adjust faces of thermometer and gages to proper angle for best visibility.

E. Clean windows of thermometer and gages and clean factory-finished surfaces. Replace cracked and broken window, and repair scratched and marred surfaces with manufacturer's touch up paint.

3.3. VALVE INSTALLATION REQUIREMENTS

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until 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 from fully open to fully closed positions. Examine guides and seats made accessible by such operation.

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. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

G. Install valves as indicated, according to manufacturer's written instructions.

H. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

I. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.

J. Locate valves for easy access and provide separate support where necessary.

K. Install valves in horizontal piping with stem at or above the center of the pipe.

L. Install valves in a position to allow full stem movement.

M. For chain wheel operators, extend chains to 60 inches above finished floor elevation.

N. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.

O. Install flow control valves with clearances from center line of valve to ceiling to allow servicing as required by manufacturer.

3.4. AUTOFLOW CONTROL VALVE INSTALLATION

A. Install automatic flow control valves on the return lines of coils as indicated on the contract drawings. A balancing valve on supply side is not acceptable.

B. The standard ports and handles shall clear 1-inch thick insulation. Provide handle and port extensions for all insulation over 1-inch thick.

C. Install, on the supply side of coils, a Y-strainer (40 mesh, 2 GPM or less; 20 mesh, above 2 GPM) with brass blow down valve with ¾-inch hose-end connection with cap. Inline (basket) strainer is not acceptable.

D. Where installed in piping with a vapor barrier, field insulate valve body to prevent surface condensation.

3.5. REFRIGERANT PIPING AND ACCESSORIES INSTALLATION REQUIREMENTS

A. 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 Shop Drawings.

B. Install and test refrigerant piping according to ASHRAE 15.

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. All exposed piping shall be hard copper tubing with brazed joints. Refer to Architectural Contract Documents to determine exposed areas.

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

F. Install piping adjacent to units to allow service and maintenance.

G. Install piping free of sags and bends. Install VEE clevis hangers and VEE troughs on pipes less than ¾"inch in diameter.

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

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

J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified if valves or equipment requiring maintenance is concealed behind finished surfaces.

L. Install refrigerant piping in protective conduit where installed below ground.

M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

N. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

O. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

P. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

Q. Identify refrigerant piping and valves.

R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section, “Common Work Results for HVAC”.

S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section, “Common Work Results for HVAC”.

T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section, “Common Work Results for HVAC”.

U. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6m) long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6m) or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6m) or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

V. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS ½ (DN 15): Maximum span, 60 inches (1500mm); minimum rod size, ¼ inch (6.4mm).
2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500mm); minimum rod size, ¼ inch (6.4mm).
3. NPS 1 (DN 25): Maximum span, 72 inches (1800mm); minimum rod size, ¼ inch (6.4mm).
4. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400mm); minimum rod size, 3/8 inch (9.5mm).
5. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400mm); minimum rod size, 3/8

inch (9.5mm).

6. NPS 2 (DN 50): Maximum span, 96 inches (2400mm); minimum rod size, 3/8 inch (9.5mm).
7. NPS 2-½ (DN 65): Maximum span, 108 inches (2700mm); minimum rod size, 3/8 inch (9.5mm).
8. NPS 3 (DN 80): Maximum span, 10 feet (3m); minimum rod size, 3/8 inch (9.5mm).
9. NPS 4 (DN 100): Maximum span, 12 feet (3.7m); minimum rod size, 1/2 inch (13mm).

W. For all interior refrigerant pipe/tubing that is less than 3/4inch in diameter, utilize VEE type clevis hanger Model 200 V and VEE type trough Model 200 VT; as manufactured by Carpenter and Patterson or approved equal. VEE trough materials shall be carbon steel with pre-galvanized finish. Install as required to maintain maximum hanger spacing requirements.

X. Support multifloor vertical runs at least at each floor.

Y. Furnish and install complete refrigerant piping systems between the indoor units and outdoor units. Support piping in accordance with Division 23 Section, HVAC Piping, Fittings, Valves, Etc. Piping shall be sized as recommended by unit manufacturer taking into account length of vertical and horizontal runs, and refrigerant type. Provide and install dual sets of refrigerant piping on all units required to have dual independent circuits.

Z. Furnish and install all required piping accessories including, but not limited to, thermal expansion valves, Sporlan, or approved equal; Packless isolation valves at condenser and evaporator coil, Henry or approved equal, charging valve with chained seal cap, Henry or approved equal, sight glasses, Henry or approved equal; filter dryer with replaceable cartridge, Sporlan, or approved equal, liquid line solenoid valve l20V/1/60 Hz., Sporlan, or approved equal. Contractor shall provide traps and double suction risers if required by equipment manufacturer. Pitch piping for proper oil return. Submit shop drawings on all components, and piping arrangements.

AA. All accessories shall be ARI rated. Furnish required nitrogen and refrigerant to fully test and charge system. Flood piping system with nitrogen when brazing.

BB. Refrigerant piping shall be Type 1 hard temper (ACR) copper tubing with wrought copper brazed fittings. Make joints with brazed wrought copper fittings.

CC. Refrigerant piping shall be cleaned, dehydrated and evacuated. Piping shall be evacuated and held to less than 2.5 mm Hg vacuum for a period of not less than 12 hours without appreciable pressure rise. Vacuum shall then be broken with refrigerant or dry nitrogen and re-evacuated to 2.5 mm Hg vacuum for an additional 12 hours. Piping test to be witnessed by Owner's representative and documented in writing. Submit results of tests to Architect/Engineer.

DD. All refrigerant/suction lines sets shall be fully insulated. Exterior pipe insulation shall be fully jacketed as specified in Division 23 Section, “HVAC Insulation”. Exposed interior pipe insulation shall be fully jacketed as specified in Division 23 Section, “HVAC Insulation”.

EE. Follow ASHRAE 15, latest edition procedures for charging and purging of systems and for disposal of refrigerant.

FF. Provide replaceable cartridge filter-driers, with isolation valves and valved bypass.

GG. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.

HH. Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.

II. Install flexible connectors at right angles to axial movement of compressor, parallel to crankshaft.

JJ. Fully charge completed system with refrigerant after tested.

KK. Provide electrical connection to solenoid valves.

LL. Install liquid indicators in liquid line leaving condenser, in liquid line leaving **[receiver]**, and on leaving side of liquid solenoid valves.

MM. Install strainers immediately upstream from each automatic valve, including expansion valves, solenoid valves, hot-gas bypass valves, and compressor suction valves.

NN. Install strainers in main liquid line where multiple expansion valves with integral strainers are used.

OO. Install moisture-liquid indicators in liquid lines between filter-dryers and thermostatic expansion valves and in liquid line to receiver.

PP. Install flexible connectors at or near compressors where piping configuration does not absorb vibration.

QQ. Test and inspect refrigerant piping according to ASME B31.5, Chapter VI.

1. Test refrigerant piping, and specialties. Isolate compressor, condenser, evaporator, and safety devices from test pressure.
2. Test high- and low-pressure side piping of each system at not less than the lower of the design pressure or the setting of pressure relief device protecting high and low side of system.

    a. System shall maintain test pressure at the manifold gage throughout duration of test.
    b. Test joints and fittings by brushing a small amount of soap and glycerin solution over joint.
    c. Fill system with nitrogen to raise a test pressure of 150 psig (1035 kPa) or higher as required by authorities having jurisdiction.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

RR. Adjust thermostatic expansion valve to obtain proper evaporator superheat requirements.

SS. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

TT. Adjust set-point temperature of the conditioned air or chilled-water controllers to the system design temperature.

UU. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Check compressor oil level above center of sight glass.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves, except bypass valves that are used for other purposes.
5. Check compressor-motor alignment, and lubricate motors and bearings.

VV. Before installing copper tubing other than Type ACR, clean tubing and fittings with trichloroethylene.

WW. Replace core of filter-dryer after system has been adjusted and design flow rates and pressures are established.

XX. Charge system using the following procedures:

1. Install core in filter-dryer after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to a vacuum of 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
4. Charge system with a new filter-dryer core in charging line. Provide full-operating charge.

3.6. PIPE JOINTS INSTALLATION REQUIREMENTS

A. Welded Joints: Joints in piping 2-1/2-inches and larger shall be fusion welded. Welding shall be in accordance with recommendations of the American Welding Society. Welding fittings shall conform in physical and chemical properties to the latest revisions of the American Society for Testing Materials.

B. Qualify welding procedures, welders and operators in accordance with ASME B31.1, or ASME B31.9 as applicable, for shop and project site welding of piping work. Certify welding of piping work using Standard Procedure Specifications by, and welders tested under supervision of, National Certified Pipe Welding Bureau (NCPWB). Submit welders qualifications for approval.

C. Grooved Joints: Grooved joint shall be installed in accordance with the manufacturer's written recommendations. Grooved ends shall be clean and free from indentations, projections, or roll marks. The gasket shall be molded and produced by the coupling manufacturer of an elastomer suitable for the intended service. The coupling manufacturer's factory trained representative shall provide on-site training for the contractor's field personnel in the use of grooving tools and installation of product. The representative shall periodically visit the job site to ensure best practices in grooved product installation are being followed. (A distributor's representative is not considered qualified to conduct the training.)

D. Screwed Joints: All screwed joints shall be made with tapered threads properly cut. Screwed joints shall be made perfectly tight with a stiff mixture of graphite and oil, applied with a brush to the male threads on the fittings.

E. Brazed Joints and Copper Piping: Joints in copper piping shall conform to the following minimum standards.

1. The pipes shall be cut to a length making certain that the ends are square, using a fins hacksaw blade or tube cutter. The ends of all pipes shall be reamed and all burrs removed.
2. The outside end of the pipe and the cut end of the fitting shall be cleaned with steel wool, sand cloth, or steel wire brush. All dark spots shall be removed.
3. The flux shall be applied evenly and sparingly to the outside end of the pipe and the inside of the outer end of the fitting until all surfaces to be jointed are completely covered. The piping and fitting shall be slipped together and reworked several times to insure an even distribution of the flux.
4. The correct amount of brazing material per joint for each size pipe shall be used in accordance with the manufacturer's recommendations.
5. Brazed joints shall be made by using a direct flame from a torch.
6. On pipe sizes larger than ¼-inch, the fittings and valves in the pipe shall be moved or tapped with a hammer when the brazing material starts to melt to insure an even distribution of the brazing material.
7. The excess brazing material shall be removed while it is still in the plastic state leaving a fillet around the cup of the fitting.
8. Brazed joints shall be suitable for working pressure of 550 psig and for working temperature of not less than 250 degrees F. The type of brazing material and flux used will be submitted for approval. Type 95-5 shall be the minimum standard.
9. Lead and antimony-based solders shall not be used for potable water systems. Brazing and silver solders are acceptable.

F. Where copper piping joins steel piping, approved bronze adapters shall be used.

G. Prohibited Connections: No direct weld or brazed connections without unions or flanges, shall be made to valves, strainers, apparatus, or related equipment. Right and left couplings, long threads, or caulking of pipe threads or gasket joints will not be permitted.

3.7. HANGERS, SUPPORTS, ANCHORS, GUIDES INSTALLATION REQUIREMENTS

A. General: All hangers shall be of an approved type arranged to maintain the required grading and pitching of lines to prevent vibration and to provide for expansion and contraction. Provide protection saddles between hangers and insulation on heating water insulated pipe. Saddles shall be Grinnells Figure 173/273 or approved equal. Provide approved spacers between saddles and pipe where flexible insulation is specified. Provide insulation protection shields for insulated piping without saddles. Shield shall be Grinnell Figure 167 or as approved equal.

B. Spacing: Regardless of spacing, hangers shall be provided at or near all changes in direction, both vertical and horizontal, for all piping.

C. Vertical Lines: Shall be supported at their bases, using either a suitable hanger placed in a horizontal line near the riser, or a base type fitting set on a pedestal, foundation or support. All vertical lines extending through more than one floor level shall be supported at each floor with a riser clamp. Riser clamp shall be Grinnell Co.'s Figure 261, or approved equal. All vertical drops to pump suction elbows shall be supported by floor posts.

D. Racks and Brackets: All horizontal piping on vertical walls shall be properly supported by suitable racks securely anchored into the wall construction. Where not practical to obtain ceiling anchorage, all piping near walls shall be supported by approved brackets securely anchored into the wall construction. Washer plates (Fib. 60, 60L) and other miscellaneous attachments, fasteners, etc., shall be Grinnell or as approved equal. All exterior hanger and bracket systems in their entirety shall be galvanized.

E. Pipe Hangers and supports shall be attached to the panel point at the top chord of bar joist or at a location approved by the structural engineer.

F. Select hangers and components for loads imposed. Secure rods with double nuts.

G. Support of horizontal piping shall allow for vertical adjustment after installation of piping.

H. Support overhead piping with clevis hangers.

I. Do not support all parallel piping from the same joist. Stagger all supports in accordance with the structural engineer's recommendations.

J. Install guides on piping adjoining expansion fittings and loops.

K. Attach guides to pipe and secure to building structure.

L. 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.

M. 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.

N. Construct concrete anchors of poured in place concrete of dimensions indicated and include embedded fasteners.

O. Install pipe anchors according to expansion fitting manufacturer's written instructions if expansion fittings are indicated.

P. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

Q. Refer to structural documents for appropriate connection/attachment materials to building.

3.8. AIR VENTING INSTALLATION REQUIREMENTS

A. The top of each hydronic water supply and return piping and other points as indicated or where necessary for the removal of air from the system or equipment, shall be vented using an approved type of manual air vent.

B. In addition to manual air vents at high points of system, each item of water heat transfer equipment shall be manually vented using an approved type manual air vent. All air vents shall be accessible.

3.9. EXPANSION LOOPS AND SWING CONNECTION INSTALLATION REQUIREMENTS

A. Install expansion fittings according to manufacturer's written instructions.

B. Install expansion fittings in sizes matching pipe size in which they are installed.

C. Align expansion fittings to avoid end loading and torsional stress.

D. 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.

E. 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.

F. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

G. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

H. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.10. PIPING IDENTIFICATION INSTALLATION REQUIREMENTS

A. All piping shall be identified with painted background marked with the name of the service with arrows to indicate flow direction. Color code and system identification shall comply with ANSI Standards and piping identification system shall comply with ASME A13.1-81., scheme for the identification of piping systems and ASHRAE Fundamentals Handbook, latest edition.

B. Markings shall be plain block letters, stenciled on pipes, and shall be located near each branch connection, near each valve, and at least every 10 feet on straight runs of pipe. Where pipes are adjacent to each other, markings shall be neatly lined up. All markings shall be located in such manner as to be easily legible from the floor. Pipe identification schedule shall be as follows:

OUTSIDE DIAMETER OF PIPE OR COVERING (INCHES)	LENGTH OF COLOR FIELD (INCHES)	SIZE OF LETTERS (INCHES)
½ to 1 ¼	8	½
1-½ to 2	8	¾
2 ½ to 6	12	1 ¼
8 to 10	24	2 ½
Over 10	32	3 ½

3.11. VALVE IDENTIFICATION REQUIREMENTS

A. All valves shall be tagged with a numbered tag.

B. The tags shall be made of 1-inch diameter brass tags fastened to the valve by means of brass chains. Numbers shall agree with valve numbers on diagrammatic herein before specified.

C. Provide a minimum of six (6) valve charts with valve numbers indicating valve type, size, manufacturer and service.

D. Additional valve charts shall be mounted behind glazed wooden frames and be hung in each mechanical equipment room including each air handling unit mechanical equipment room. Additional copies shall be provided in each copy of the O&M manuals.

3.12. PRESSURE SEAL FITTING INSTALLATION REQUIREMENTS

A. Viega, ProPress Pressure Seal bronze or copper fittings: Sealing element shall be verified for the intended use. Tube ends shall be cut on a right angle (square) to the tube. Tube ends shall be reamed and chamfered, all grease, oil or dirt shall be removed from the tube end with a clean rag. Visually examine the fitting sealing element to ensure there is no damage, and it is properly seated into the fitting. Utilizing a Viega Insertion Depth Inspection Gauge mark the tube wall, with a felt tip pen, at the appropriate location, or insert the tube fully into the fitting and mark the tube wall at the face of the fitting. Always examine the tube to ensure it is fully inserted into the fitting prior to pressing the joint. ProPress fittings ½-inch thru 4-inch shall be installed according to the most current edition of the Viega installation guidelines, using appropriate sized rigid ProPress tools. Installers shall attend a Viega ProPress installation training class.

B. After ProPress Pressure Seal fittings have been installed a "two step test" shall be followed. Pressurize the system with application appropriate test medium, water between 15 and 85 psi, or air/dry nitrogen between .5 and 45 psi. Check the pressure gauge for pressure loss. If the system does not hold pressure, walk the system and check for un-pressed fittings. Should you identify an un-pressed fitting ensure the tube is fully inserted into the fitting, and properly marked, prior to pressing the joint. After appropriate repairs have been made, retest the system per specification requirements, not to exceed 600 psi with water.

3.13. CLEANING/FLUSHING/PURGING PIPING AND EQUIPMENT

A. The Contractor shall submit a detailed written flushing plan including shop drawings depicting locations of temporary bypasses, strainers, vents, drains, isolation valves and temporary spool pieces for review and approval by the Engineer of Record.

B. All dual temperature and geothermal systems shall be cleaned by filling with a solution of one (1) pound of trisodium phosphate to each 50 gallons of water and circulating this solution for a period of five (5) days during which time the system shall reach operating temperature. The systems shall then be flushed with fresh water and refilled with fresh water and antifreeze and purged of all air.

C. Any equipment, such as coils that have small tubing, shall be bypassed to prevent deposition of debris from the piping. Water balancing shall not be scheduled until the completion of the cleaning and treatment process.

D. All strainers shall be inspected and cleaned prior to testing and balancing. In addition, prior to substantial completion, contractor must inspect and clean all strainers.

E. Flushing & Treatment:

1. The dual temperature and geothermal systems shall be thoroughly flushed and treated.
2. Flushing and Treatment shall be witnessed by representatives of the Mechanical Contractor, Chemical Treatment Contractor, Engineer of Record, and Owner.
3. The phasing layout and complexity of the piping system may require the system to be separately flushed in sections.

F. Chemical Water Treatment Contractor:

1. The Contractor shall submit to the Engineer of Record the Proposed Chemical Treatment Contractor Company information and Qualifications along with the proposed chemical cleaning, dispersant, & inhibitor brands and concentrations of the chemicals for review and approval.

G. Pumps:

1. Temporary Pump System:

a. The incorporation and use of temporary pump systems is recommended for the flushing & cleaning process. The Contractor shall size the temporary pump system to ensure a fluid velocity of 6 FPS through the largest pipe diameter in the system.

b. The Contractor shall submit documentation to the Engineer of Record for approval of the proposed temporary pump system. This shall include pump curves, flow meters to prove the required velocity, pressure gauges, connection details and temporary power requirements along with a written description and photos of the proposed temporary pump system.

2. Permanent Facility Pump Systems:

a. In the event temporary pumps cannot be utilized for the flushing and cleaning process, the existing permanent facility pump systems may be used only with prior approval of the Engineer of Record. The Contractor shall submit documentation to the Engineer of Record for approval of the proposed use of the Permanent Facility pump system. This shall include verification that the permanent facility pump system is capable of achieving the required fluid velocity of 6 FPS through the largest pipe diameter in the system, pump curves, flow meters to prove the required velocity, pressure gauges, connection details and power requirements along with a written description and photos of the proposed Permanent Facility pump system.

b. In exchange for the use of the permanent facility pump system, The Contractor shall engage the Pump Manufacturer at the end of the cleaning/flushing process to disassemble the pump bodies and fully inspect the condition of the impellers, seals, bearings, wear rings, and motors for any damage caused by the flushing process. The Pump Manufacturer shall provide a written report with documenting photos of the condition of the pump system to the Engineer of Record. The permanent facility pumps must be in new condition and unconditionally warranted for a period of 2 years from the date of Project Substantial Completion. In the event a pump or pumps fail and is proven to be a result of the cleaning/flushing process during the 2 year warranty period the Contractor shall provide an additional 2 year extended warranty from the date of repair/replacement on the failed pump system.

H. Bypasses, Vents, Drains, Strainers, Isolation Valves, Temporary Spool Pieces & Hoses:

The Contractor shall prepare the piping system to ensure equipment and fragile devices are protected from damage caused by the flushing process.

1. The Contractor shall isolate & bypass all major equipment, heat pumps, ERV units, make-up air units, coils, ancillary equipment, control valves, check valves, insertion type & inline flow meters and any other fragile device that may be damaged as a result of the cleaning/flushing process. The Contractor shall incorporate the use of Line Size temporary flanged / union spool pieces in locations where fragile devices were removed.

2. The Contractor shall install high point air vents and low point drains where required. The layout of the piping system may require additional secondary high point vents and low point drains to ensure the system can be fully vented and

drained during the cleaning/flushing process. The Contractor shall depict on the Flushing procedure shop drawings all required and secondary vents & drains. Secondary vents and drains shall be at No additional costs to the Owner.

3. The Contractor shall provide and install strainers where required.

I. Flushing Operation:

1. Pre Flush - Bypass loops should be installed at all equipment components. Strainers can be removed when a self-contained purge unit is used in conjunction with on board filtration. Flush ports should be identified along with the type of high pressure hose or piping that will be used to connect to the system. The water source should be identified and must be adequate to fill and make up water in a timely manner to the system during the flush process.
2. Clear Water Flush – Fill the piping system with clean potable water. The first flush is a clear- water flush intended to circulate water through the system and force loose debris to low point drains and the flush cart filtration system. This flush should be at minimum velocity throughout the system of 5 to 7 ft/sec. Filtration size shall be 25 micron.
3. Cleaning & Passivation - The second flush cycle is a combined flushing cycle where cleaning and passivation chemicals are introduced into the system to clean the oils and treat the inside wall of the piping system. This process will be monitored by the chemical treatment company to meet the chemical specifications of the water. The cleaning velocity should be between 3 to 5 ft/sec and the circulation time will be based on the chemical testing but will typically be up to 48 hours.
4. A circulation pump shall be sized to meet a fluid velocity of 6 FPS in the largest pipe main. Add by-pass piping for continuous circulation at each end where required.
5. The system shall be filled from the lowest available point; all vents and high point connections shall be open during this operation to allow the air in the system to vent off. Fill system with fresh water and circulate for 12-24 hours and flush to remove large sediment first.
6. Drain system from all lowest possible points and refill with fresh water.
7. Add a System Cleaner/Dispersant: Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products, similar to Bond - 8050 Closed System Cleaner, at a dosage of 15 gallons per 1000 gallons of system volume, and circulate for 24 hours.
8. All new installed equipment (such as water source heat pumps, HX's, expansion tanks, etc.) which are not to be subjected to chemical cleaning and flushing, shall be disconnected from the piping. Add by-pass loops at each branch pipe to ensure continuous circulation of flushing fluids. Circulating pump must run continuously during the entire cleaning and flushing procedure to assure proper cleaning.
9. Drain system from all of the lowest points until the pH is equal to fresh potable water make-up (< 8.0).
10. Circulate the system water again after flushing for 12 hours, then drain system again if water is still turbid.
11. If system water is clean at test valves on lower section of system proceed to step 13. If the system is still turbid fill circulate for another 12 hours and flush until it is clear.
12. Refill system with fresh water and add corrosion inhibitor, similar to Bond-5010 Molybdum, to system water to achieve the desired residual (50-150ppm).

13. The system must be tested after 2-3 weeks of operation to ensure the chemical residual is adequate and maintained.
14. Submit Piping System Flushing report of cleaning and flushing. Report is to include largest main, circulation pump sizing (flow and head), system volume (in gal), amount of cleaning agent added (in gal), flush start date and time and end date and time, amount of chemical added, water quality parameters and chemical residual after 2 week operation period.
15. Treatment – After cleaning and before adding chemical initial charge, system must be flushed to meet these minimum requirements:

    a. Conductivity no higher than 20 micromhos above domestic water level
    b. No foam
    c. Copper level less than 0.5 ppm
    d. Iron level less than 1.0 ppm
    e. pH 9.4 or less
    f. Less than 1 ppm phosphates (ortho-phosphate PO4)

16. Final Clear Water Flush – The system will be continuously flushed while discharging chemicals into the sanitary system as approved locally. As the existing treated water is being discharged a fresh water make-up source will be utilized to ensure air is not introduced into the system. Continue to drain the system while adding domestic water to dilute the treated water. The chemical treatment company will monitor the outgoing water composition and compare the composition with the incoming water. Flush with fresh water until the conductivity is reduced to that of the make-up water and iron level is 1.0 ppm or less the final system water should be approved by the chemical treatment company. Filtration should be 5 micron.
17. Final Chemical Fill – Once the chemical treatment company has determined the system has been brought back to the correct composition, the chemical treatment company will inject the final chemicals into the system. Once the system is filled with the final chemicals it is important that the water is not to be left stagnant.
18. Verify satisfactory completion of clean pipe and a final flushing and chemical treatment report should be signed by field personnel and submitted.
19. Treat and test dual temperature/geothermal systems monthly for the entire 24 month warranty period.

END OF SECTION

DIVISION 23 SECTION 23 05 48
VIBRATION CONTROLS FOR HVAC, PLUMBING & FIRE PROTECTION EQUIPMENT
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SECTION 23 05 48 – VIBRATION CONTROLS FOR HVAC, PLUMBING AND FIRE PROTECTION EQUIPMENT

PART 1. RELATED DOCUMENTS

1.1. GENERAL

A. Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections apply to work of this section.

B. All work under this section shall also be subject to the requirements of Division 23 Section, Common Work Results for HVAC.

1.2. SUMMARY

A. Provide all labor and materials necessary to furnish and install vibration control systems on this project as herein specified and/or shown on the drawings.

B. Mount all mechanical equipment on suitable vibration isolators so as to prevent transmission of vibration into or through the building structure. Isolators shall be as manufactured by Mason Industries, Inc., Korfund, Inc., Amber Booth, Vibration Mounting and Controls, or approved equal, and shall be selected by the isolator manufacturer for each item of equipment in accordance with requirements hereinafter specified.

C. The equipment manufacturer shall supply all pump and motor bases, fan and motor bases, cradles, isolation pipe/duct hangers, spring and/or neoprene isolators, neoprene pads, flexible connectors, etc. as a coordinated package by a single manufacturer.

D. Select isolators for uniform static deflections according to distribution of weight; and for not less than the indicated isolation efficiency with the lowest rotational speed of equipment as the disturbing frequency.

E. Isolators and bases shall be stable during stopping and starting of equipment without transverse or eccentric movement of equipment, and shall be designed to resist horizontal forces of equipment which may operate unbalanced.

F. In general, select isolators on the basis of criteria as specified in the ASHRAE Applications Handbook, Latest Edition.

1.3. SUBMITTALS

A. Shop Drawings: Indicate inertia bases and locate vibration isolators, with static and dynamic load on each.

B. Product Data: Provide schedule of vibration isolator type with location and load on each.

C. Manufacturer’s Installation Instructions: Indicate special procedures and setting dimensions.

D. Manufacturer’s Certificate: Certify that isolators are properly installed and adjusted to meet or exceed specified requirements.

1.4. PROJECT RECORD DOCUMENTS

A. Record actual locations of hangers including attachment points.

1.5. COLOR CODING

A. All springs shall be color coded for load carrying capacity.

1.6. ALTERNATES

A. Refer to Division 01 Section, Alternates - Alternates for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. MANUFACTURERS

A. Isolators shall be the equivalent of the following types by Mason Industries, Inc., Korfund, Inc., Kinetic Noise Control, Inc., Vibro Acoustics or approved equal.

2.2. CORROSION PROTECTION FOR STEEL PARTS

A. Where steel parts are exposed to weather or humid environments provide hot-dipped galvanized coating of at least 2 ounces of zinc per square foot of surface. Coat springs with neoprene.

2.3. SPRING MOUNTS AND SOUND PADS

A. Provide all spring mounts with leveling devices, minimum .25 inch thick neoprene sound pads, and zinc chromate plated hardware.

B. All sound pads shall be size for minimum deflection of .05 inch; meet requirements for neoprene pad isolators.

2.4. SPRINGS

A. All springs shall have minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between .3 and .6 of maximum deflection.

2.5. NEOPRENE

A. Grade durometer 40, 50 OR 60 AND OIL RESISTANT.

2.6. FLOOR MOUNTED ISOLATORS:

A. Neoprene Isolation Pads: Provide pads at least ¼ " thick with cross-ribbed or waffle design. For concentrated loads provide steel bearing plates bonded or cold cemented to the pads. Neoprene isolation pads shall be Type Super W.

B. Neoprene Isolators: Rubber (neoprene)-in-shear mounting: Provide molded neoprene isolators having steel base plates with mounting holes and, at the top, steel mounting plates with mounting holes or threaded inserts. Provide elements of type and size coded with molded letters or color-coded for capacity identification. Embed metal parts completely in neoprene. Double deflection neoprene mountings shall have a minimum static deflection of 0.35". Bolt holes shall be provided for these areas where bolting is required. On equipment such as small vent sets and close coupled pumps, steel rails shall be used above the mounting to compensate for the over-hang. Mountings shall be type ND or rails type DNR.

2.7. SPRING ISOLATORS

A. General: Provide spring isolators or protected spring isolators that are adjustable and laterally stable with free-standing springs of horizontal stiffness at minimum 80 percent of the vertical (axial) stiffness. For machine-attached and floor-attached restraining elements, separate from metal-to-metal contact by neoprene cushions 1/8-inch thick minimum. Provide neoprene acoustic friction pads at least ¼ inch thick.

B. Spring Isolator: Spring type isolators shall be free standing and laterally stable without any housing and complete with ¼ " neoprene acoustical friction pads between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflections, compressed spring height and solid spring height. Mountings shall be type SLF as manufactured by Mason Industries, Inc. or as approved equal.

2.8. SUSPENSION ISOLATORS

A. General: Provide hangers with suspension isolators encased in open steel brackets. Isolate hanger rods from isolator steel brackets with neoprene-lined opening.

B. Suspension Neoprene Isolators: Provide double-deflection elements with minimum 3/8 inch deflection.

C. Suspension Spring Isolators: Vibration hangers shall contain a steel spring and 0.3" deflection neoprene element in series. The neoprene element shall be molded with a rod isolation bushing that passes through the hanger box. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing thru a 30° arc before contacting the hole and short circuiting the spring. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include a scale drawing of the hanger showing the 30° capability. Hangers shall be type 30N.

D. Precompressed Suspension Spring Isolators: Vibration hangers shall be as described in "C" above, but they shall be precompressed to the rated deflection so as to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a scale drawing of the hanger showing the 30° capability. Hangers shall be type PC30N.

E. Ductwork Suspension Spring Isolators: Vibration hangers shall contain a steel spring located in a neoprene cup manufactured with a grommet to prevent short circuiting of the hanger rod. The cup shall contain a steel washer designed to properly distribute the load on the neoprene and prevent its extrusion. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing thru a 30° arc before contacting the hole and short circuiting the spring. Spring shall have a minimum additional travel to solid equal to 50% of the rated deflection. Hangers shall be provided with an eye bolt on the spring end and provision to attach the housing to the flat iron duct straps. Submittals shall include a scale drawing of the hanger showing the 30° capability. Hangers shall be type W30.

2.9. THRUST RESTRAINTS

A. Adjustable spring thrust restraints, able to resist the thrust force with at least 25 percent unused capacity. The operating spring deflection shall be not less than 50 percent of the static deflection of the isolation supporting the machinery. The spring element shall be contained within a steel frame and designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of ¼" movement at start and stop. The assembly shall be furnished with one rod and angle bracket for attachment to both the equipment and ductwork or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrically on either side of the unit. Horizontal thrust restraints shall be type WB.

2.10. INERTIA BASES

A. Structural Bases: Vibration isolator manufacturer shall furnish integral structural steel bases. Bases shall be rectangular in shape for all equipment other than centrifugal refrigeration machines and pump bases which may be "T" or "L" shaped. Pump bases for split case pumps shall include supports for suction and discharge base ells. All perimeter members shall be beams with a minimum depth equal to 1/10th of the longest dimension of the base. Beam depth need not exceed 14" provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of one inch- bases shall be type WF.

B. Structural Rails: Vibration isolator manufacturer shall provide steel members welded to height saving brackets to cradle machines having legs or bases that do not require a complete supplementary base. Members shall be sufficiently rigid to prevent strains in the equipment. Inverted saddles shall be type ICS.

C. Concrete Bases: Vibration isolator manufacturer shall furnish rectangular structural beam or channel concrete forms for floating foundations. Bases for split case pumps shall be large enough to provide support for suction and discharge base ells. The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity. In general, bases shall be a minimum of 1/12th of the longest dimension of the base, but not less than 6". Forms shall include minimum concrete reinforcement consisting of half inch bars or angles welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom, or additional steel as is required by the structural conditions. Forms shall be furnished with steel members to hold anchor-bolt sleeves when the anchor bolts fall in concrete locations. Height saving brackets shall be employed in all mounting locations to maintain a 1" clearance below the base. Concrete shall be 3,000 psi concrete. Mass of concrete inertia bases shall be minimum of 2 times weight of isolated equipment. Bases shall be type K.

2.11. FLEXIBLE CONNECTORS FOR PIPING

A. General: Straight or elbow flexible connectors rated for temperatures, pressures, and fluids to be conveyed. Provide flexible connectors with the strength 4 times operating pressure at highest system operating temperature. Provide elbow flexible connectors with a permanently set angle.

B. Elastomeric Flexible Connectors: Flexible neoprene connectors shall be manufactured of multiple plys of nylon tire cord fabric and neoprene both molded and cured in hydraulic rubber presses. No steel wire or rings shall be used as pressure reinforcement. Straight connectors shall have two spheres. Connectors up to and including 1 ½ " diameter may have threaded ends. Connectors 2" and larger shall be manufactured with floating galvanized flanges recessed to lock the connector's raised face neoprene flanges. Hoses shall be installed on the equipment side of the shut-off valves. Connectors shall be rated a minimum of 150 psi at 220°F. Flanged equipment shall be directly connected to neoprene elbows in the size range 2 ½ " through 12" if the piping makes a 90o turn at the equipment. All straight through connections shall be made with twin-spheres properly pre-extended as recommended by the manufacturer to prevent additional elongation under pressure. 12" and larger sizes operating above 100 psi shall employ control cables with end fittings isolated by means of ½ " thick bridge bearing neoprene washer bushings designed for a maximum of 1000 psi.

C. Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies.

D. Elbows shall be Mason-Flex type MFNEC, straight connectors Mason-Flex type MFTFU or MFTNC, and control cable assemblies type ACC.

E. Metal Flexible Connectors: Fabricated of Grade E phosphor bronze, monel or corrugated stainless steel tube covered with comparable bronze or stainless steel braid restraining and pressure cover. Sizes 3" and larger shall be flanged. Sizes 2 ½ " and smaller shall have male nipples. Lengths shall be as indicated:

Nominal Diameter (Inches)	Length (Inches)
½ "	12"
3/4"	12"
1 ½ "	12"
1 ½ "	12"
2"	12"
2 ½ "	12"

3"	18"
4"	18"
5"	24"
6"	24"
8"	24"
10"	24"
12"	36"
14"	36"
16"	36"

F. Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible. Hoses shall be type BSS.

2.12. NEOPRENE PAD ISOLATORS

A. Rubber or neoprene waffle pads.

1. 30 durometer
2. Minimum 2 inch (13mm) thick
3. Maximum loading 40 psi (275 kPa)
4. Height of ribs shall not exceed 0.7 times width.

B. Configuration: ½ inch (13mm) thick waffle pads bonded each side of ¼ inch (6 mm) thick steel plate.

2.13. RUBBER MOUNTS

A. Molded rubber designed for 0.6 inches (13 mm) deflection with threaded insert.

PART 3. EXECUTION

3.1. GENERAL PROVISIONS

A. Install vibration-and-noise isolation materials and equipment as indicated and in accordance with machinery manufacturer's instructions.

B. Where neoprene elements of vibration isolator may be subjected to high pipe temperatures above 160°F, provide metal heat shields or thermal isolators.

C. A minimum of 4" thick reinforced concrete housekeeping pads shall be provided under all floor mounted equipment. Rest subbases on structural floor and reinforce with steel rods interconnected with floor reinforcing bars by tie bars hooked at both ends. Provide at least one (1) inch clearance between subbases and inertia bases, steel bases, and steel saddles with machinery in operation.

D. All vibration isolators exposed to weather or humid environment shall be hot dipped galvanized with springs coated with neoprene in accordance with paragraph hereinbefore described.

E. Concrete inertia bases shall be a minimum of two (2) times the weight supported. Clearance between the underside of the inertia base and the housekeeping pad below shall not be less than 1 inch. Concrete shall be 3000 psi. Install inertia bases in accordance with the recommendations of the machinery manufacturer and the inertia base manufacturer.

F. Anchor Bolts and Grout: Secure machinery to foundations and inertia bases with anchor bolts. Grout equipment with baseplates, the full area under baseplates with premixed non-shrinking grout. After grout has set, remove wedges, shims, and jack bolts and fill spaces with grout.

G. Common Machinery Foundations: Mount electrical motors on the same foundations as driven machinery. Support piping connections, strainers, valves, and risers on the same foundation as the pumps.

H. Thrust Restraints: Where required, provide pairs of thrust restraints, symmetrically installed on both sides of the steady state line of thrust.

I. Machinery: Provide vibration isolators, flexible connectors and seismic snubbers in accordance with manufacturer's recommendations. Machinery with spring isolators or protected spring isolators shall rock or move freely within limits of stops or seismic snubber restraints.

J. Stability: Isolators shall be stable during starting and stopping of machinery without traverse and eccentric movement of machinery that would damage or adversely affect the machinery or attachments.

K. Lateral Motion: The installed vibration isolation systems for each piece of floor or ceiling mounted machinery shall have a maximum lateral motion under machinery start up and shut down conditions of not more than ¼ -inch. Restrain motions in excess by approved spring mountings.

L. Unbalanced Machinery: Provide foundation suspension systems specifically designed to resist horizontal forces for machinery with large unbalanced horizontal forces. Vibration isolator systems shall conform to the machinery manufacturer's recommendations.

M. Nonrotating Machinery: Mount nonrotating machinery in systems which includes rotating or vibrating machinery on isolators having the same deflection as the hangers and supports for the pipe connected to.

N. Roof and Upper Floor Mounted Machinery: On the roof or upper floors, mount machinery on isolators with vertical stops. Rest isolators on beams or structures designed and installed in accordance with the SMACNA ASMM Plate 61.

O. Vibration isolation ceiling hangers shall be installed so that the hanger rods do not touch the sides of the isolator housing, thereby seriously degrading the vibration isolation performance. Vibration isolation ceiling hangers shall be located so that the hanger housing may rotate 360 degrees without touching any object.

P. Electrical Connections: Provide flexible conduit or multiple conductor cable connections for machinery with sufficient extra length to permit 2 inch minimum displacement in any direction without damage.

Q. Systems Not To Be Vibration Isolated: Do not provide vibration isolation for electrical raceways and conduits or for fire protection, storm, sanitary, and domestic water piping systems which do not include pumps or other vibrating, rotating, or pulsating equipment including control and pressure reducing valves.

R. Install in accordance with manufacturer's instructions.

S. Install isolation for motor driven equipment.

T. Bases:

1. Set steel bases for one inch (25mm) clearance between housekeeping pad and base.
2. Set concrete inertia bases for 2 inch (50mm) clearance between housekeeping pad and base.
3. Adjust equipment level.

U. Install spring hangers without binding.

V. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.

W. Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.

X. Connect wiring to isolated equipment with flexible hanging loop.

3.2. MEDIUM AND HIGH PRESSURE DUCTWORK ISOLATION (4 INCH WATER COLUMN AND ABOVE)

A. Provide vibration isolation for medium and high pressure ductwork operating with over four (4) inches water column. The isolator deflections shall be equal to or greater than the static deflection of the vibration isolators provided for the connected machinery as follows:

All discharge runs for a distance of 50' from the connection equipment (fans, exhausters and blowers) shall be isolated from the building structure. Spring deflections shall be a minimum of 0.75".

B. Ductwork Hanger and Support Installation: Provide ductwork with vibration isolation hangers and supports where located in mechanical equipment rooms. Connect ductwork to equipment with flexible duct connectors. Segment ductwork with flexible duct connectors.

C. Duct Risers: Provide duct riser supports within shafts with suitable bearing plates and two layers of ¼ " thick ribbed or waffled neoprene pad loaded to not more than 50 psi. Separate isolation pads with ¼ " steel plate.

D. Supports at Base of Duct Risers: For duct isolation supports at the base of risers, provide two layers of ¼ " thick heavy-duty neoprene pad separated by ¼ " thick steel plate. Use bearing plates sized to provide a pad loading of not more than 500 psi. Weld the stanchion between the duct and isolation support to the pipe, and weld or bolt to the isolation support. Bolt isolation support to the floor slab with resilient sleeves and washers. Where supplementary steel is required to support ducts, provide a maximum deflection of ¼ " at the midspan of this steel under the supported load. Rigidly support duct from the supplementary steel and the supplementary steel isolators.

E. Duct Anchors: Attach each end of the duct anchor to an omni-directional isolator which in turn shall be rigidly fastened to the steel framing or structural concrete as indicated. Vertical restraints shall be provided by similar material arranged to prevent vertical travel in either direction. The load on the isolation material shall not exceed 500 psi.

3.3. PIPE ISOLATION

A. Horizontal Pipe Isolation:

1. Precompressed Suspension Spring Isolators:

a. For the first three pipe hangers in the main lines near the mechanical equipment provide precompressed suspension spring isolators. Floor supported piping shall rest on trained spring isolators. All precompressed suspension spring isolators hangers or the first three trained spring isolators mounts as noted above, will have the same static deflection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceiling under occupied spaces, the first three hangers shall have 0.75" deflection for pipe sizes up to and including 3", 1.5" deflection for pipe sizes up to and including 6" and 2.5" deflection thereafter. All other hangers and mounts will have a minimum steel spring deflection of 0.75". Hangers shall be located as close to the overhead supports as practical.

2. Combination Spring and Neoprene Suspension Hanger:

a. For horizontal runs in other than those hereinbefore specified provide suspension spring hangers (combination spring and neoprene) with .75" minimum steel spring deflection.
b. Dual Temperature Water and Geothermal Interior Heat Pump Water Piping:

i. For the first 20 feet of the branch connection of the main supply and return piping at each floor.
ii. For all piping over 2" diameter.

B. Floor-Supported Piping:

1. Floor supports for piping in equipment rooms and adjacent to isolated equipment shall use vibration isolators as described hereinbefore and selected to the guidelines of hangers.
2. The first three adjacent floor supports shall be the restrained spring type with a blocking feature that prevents load transfer to equipment flanges as the piping is filled and drained.
3. Where piping is subject to larger thermal movement a slide plate shall be installed on the top of the isolator. Slide plate shall be teflon, graphite or steel.
4. Provide a thermal barrier where neoprene products are installed directly beneath steam or hot water lines.

C. Pipe Risers: Provide pipe riser supports with bearing plates and two layers of ¼ " thick ribbed or waffled neoprene pad loaded to not more than 50 psi. Separate isolation pads with ¼ " steel plate. Weld pipe riser clamps at anchor points to the pipe and to pairs of vertical acoustical pipe anchor mountings which shall be rigidly fastened to the steel framing.

D. Supports at Base of Pipe Risers: Piping isolation supports at the base of risers shall be two layers of ½" thick heavy-duty neoprene pad separated by ¼ " thick steel plate. Use bearing plates sized to provide a pad loading of not more than 500 psi. Weld the stanchion between the pipe and isolation support to the pipe and weld or bolt to the isolation support. Bolt isolation support to the floor slab with resilient sleeves and washers. Where supplementary steel is required to support piping, provide a maximum deflection of 0.08 inches at the mid-span of this steel under the load. Rigidly support piping from the supplementary steel with the supplementary steel isolated from the building structure with isolators.

E. Pipe Anchors: Attach each end of the pipe anchor to an omni-directional pipe isolator which in turn shall be rigidly fastened to the steel framing or structural concrete. Provide a telescoping pipe isolator of two sizes of steel tubing separated by a minimum ½ " thick pad of heavy-duty neoprene or heavy-duty neoprene and canvas. Provide vertical restraints by similar material to prevent vertical travel in either direction. The load on the isolation material shall not exceed 500 psi.

3.4. FLEXIBLE PIPE CONNECTORS

A. Provide flexible connectors in accordance with manufacturers instructions where piping systems serving vibration isolated equipment and as shown on the drawings. Flexible connectors shall be installed near the connection to the equipment. Where liquid pulsation dampening is required, flexible connectors with spherical configuration may be used. Provide restraints for pipe connectors at pumps to prevent connector failure upon pump start-up.

3.5. ISOLATION FOR SPECIFIC EQUIPMENT

A. The vibration isolator manufacture shall provide isolators for all pieces of equipment provided for the job. Isolator shall be selected by the isolator manufacturer on the basis of criteria as specified in the ASHRAE Applications Handbook, latest edition, unless a more stringent requirement is indicated on the drawings.

B. Pumps:

1. All base mounted pumps shall be mounted on concrete inertia bases supported on stable steel springs in series with ribbed neoprene pads selected for not less than 1.5 inch static deflection under full operating load. Mason Industries type SLF or as approved equal.
2. Floor support of the initial pipe elbows at the pump discharge and suction diffuser at the pump intake shall be made from the isolated inertia base, not from the equipment room floor. Mason Industries Type K or as approved equal.
3. Provide flexible pipe connections at pump suction and discharge. Mason Industries Type BSS or MFTNC/MFTFU with control rods type ACC or as approved equal.
4. Provide discharge and suction vibration isolaters at all in-line pumps.

C. Energy Recovery Ventilators, and Kitchen Make-up Air Units:

1. All rooftop units, energy recovery ventilators, and kitchen make-up air units shall be supported on stable steel springs in series with ribbed neoprene pads selected for not less than 2.0" deflection under full operating load. Mason Industries type SLF springs or as approved equal. Following the manufacturer's specific installation instructions for specific equipment is acceptable.

D. Ducted Heat Pumps:

1. All heat pump units shall be supported on stable steel springs in series with ribbed neoprene pads selected for not less than 1.0 deflection under full operating load. Mason Industries type SLF springs or as approved equal. Following the manufacturer’s specific installation instructions for specific equipment is acceptable.

E. Fans:

1. Fans up to 22" wheel diameter shall be mounted stable steel springs in series with ribbed neoprene pads selected for not less than 1.0" static deflection (Mason Industries Type SLF or equivalent).
2. Fans with wheel diameters 24" and greater shall be mounted on unhoused stable steel springs in series with ribbed neoprene pads and structural rails selected for not less than 1.5" static deflection (Mason Industries Type SLF or equivalent and structural rails Type ICS with thrust restraint provisions) and rails shall be Type ICS.
3. All fans suspended from the ceiling, joists or roof structure, including outside air fans, return fans, relief air, ventilation fans, and exhaust fans, shall be suspended using hangers incorporating steel springs in series with neoprene, selected for not less than 2.0" static deflection under full load (Mason Industries Type 30N or equivalent).

F. All horizontal, vertical, and recessed unit heaters shall be suspended using hangers incorporating steel springs in series with neoprene selected for not less than 1" static deflection under full load (Mason Industries Type 30N or equivalent).

G. Ductless Units: Indoor ductless units shall be supported with rubber grommet type suspension isolators. Outdoor ductless units shall be supported on ribbed neoprene pads resting on roof curbs (roof application).

H. Water to Water Heat Pumps:

1. Water to water heat pumps shall be mounted on spring isolators for not less than 1 inch static deflection under full operating load. Isolators shall be mason type SLR or as approved equal. Provide neoprene coated springs.

3.6. MANUFACTURER’S FIELD SERVICES

A. Inspect isolated equipment after installation and submit report. Include static deflections.

END OF SECTION

DIVISION 23 SECTION 23 05 93
TESTING, ADJUSTING & BALANCING FOR HVAC & PLUMBING
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SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC AND PLUMBING

PART 1. GENERAL

1.1. GENERAL

A. This section covers performance testing, adjusting and balancing of heating, ventilating, air conditioning and domestic re-circulating systems as specified in Division 23 Section, Heating, Ventilating, and Air Conditioning Equipment and in Division 22 Sections, Plumbing Fixtures and Plumbing Equipment.

B. For Common Work Results of HVAC, See Division 23. See Division 01 for General Requirements.

C. The mechanical contractor shall select and employ an impartial, independent balancing agency to provide testing and balancing services for the heating, ventilating and air conditioning (HVAC) systems, plumbing systems, and other specified systems of this project.

D. The work included in this section consists of furnishing labor, instruments, and tools required in testing, adjusting and balancing the HVAC and plumbing systems, as described in these specifications or shown on accompanying drawings. Services shall include checking equipment performance, taking the specified measurements, and recording and reporting the results. Where balance valves and/or flow meter fittings are not indicated utilize ultrasonic flow meter to record fluid flow rates in gallons per minute.

1. Perform all work required to prepare the building HVAC and Plumbing systems for testing, adjusting, and balancing indicated by the Contract Documents as follows:

a. Verify the air systems are ready for balancing.
b. Verify the hydronic systems are ready for balancing.
c. Verify the control systems are ready for balancing.
d. Notify appropriate parties the system is ready for balancing.

2. Scope of work.

a. Testing, adjusting, and balancing (TAB) of the HVAC systems, Plumbing Systems, and related ancillary equipment will be performed by an independent, third party, AABC Certified Agency, selected and employed directly by the Contractor. The preparation and corrections necessary for the testing and balancing of these systems, as described herein, are the responsibility of the Contractor.
b. As part of the project Construction Contract, the Contractor shall make any changes or replacements to the sheaves, belts, dampers, valves, or other components required for correct balance as advised by the TAB Agency, at no additional cost to the Owner.
c. The Contractor shall provide and coordinate the services of qualified, responsible subcontractors, suppliers and personnel as required to correct, repair, and/or replace any and all deficient items or conditions found during the course of this project, including the testing, adjusting, and

balancing period.

d. In order that all systems may be properly tested, adjusted and balanced as required herein by these Specifications, the Contractor shall operate the systems at their expense for the length of time necessary to properly verify their completion and readiness for TAB, and the entire duration required for the TAB process.

e. Project Contract completion schedules shall allow for sufficient time to permit the completion of TAB services prior to Owner occupancy. The Contractor shall allow adequate time for the testing and balancing activities of the Owner-provided services during the construction period and prior to Substantial Completion, as defined in the AIA General Conditions and Supplementing Condition of this Construction Document.

f. The Drawings and Specifications indicate valves, dampers, and miscellaneous adjustment devices to be adjusted to obtain optimum operating conditions. It is the responsibility of the Contractor to install these devices in a manner that will leave them accessible and readily adjustable. Should any such device not be readily accessible, the Contractor shall provide access, as requested by the TAB Agency. Any malfunction encountered by TAB personnel and reported to the Contractor shall be corrected by the Contractor immediately so that the balancing work can proceed with a minimum of delays.

g. The scope of work, as defined herein, is to advise the Contractor of the coordination, adjustment, and system modifications that will be required under the project work to complete Owner requirements for final TAB. The Contractor's original bid shall allow for the costs of all work which may be required in the TAB phases, and which may be necessary for the completion of the TAB work as defined by the TAB Agency.

3. Submittals. The TAB Agency shall submit an agenda that will include:

a. Field observation reports.

b. An overview of system TAB procedures.

c. System testing which will include where ducts will be traversed, which instrumentation will be used, how correction factors for grille and diffuser will be obtained, how measurements will be verified at maximum and minimum, and how control components will be verified.

d. Report forms with each system's components identified and numbered.

E. The items requiring testing, adjusting, and balancing include, but are not limited to, the following:

<u>Air Systems</u>:

1. Air Flow Monitoring Stations
2. Air Handling Units
3. Coils (Air Temperatures & Static Pressure Drops)
4. Diffusers, Registers and Grilles
5. Dishwashing Machine Hoods
6. Dryer Duct Booster Fans
7. Duct Smoke Detectors
8. Ductless Split System Units (Indoor and Outdoor units)
9. Energy Recovery Ventilators

10. Electric Unit Heaters
11. Exhaust Fans
12. Fans
13. Fire Dampers
14. Geothermal Heat Pumps
15. Hot Gas Re-heat Coils
16. Heat Recovery Systems
17. Heat Pumps
18. Heat Pipes
19. Intake Hoods
20. Kiln Hoods
21. Kitchen Hoods
22. Kitchen Make-up Air Units
23. Pressure Independent Control Valves
24. Radiant Heat Panels
25. Relief Fans
26. Relief Hoods
27. Rooftop Geothermal Units
28. Static Pressure Gauge (Dish Machine Canopy Hood)
29. Supply Fan AHU
30. Unit Heaters
31. Ventilation Fans
32. Zone Branch and Main Ducts

<u>Hydronic Systems:</u>

1. Air Handling Units
2. Autoflow Valves
3. Automatic Glycol Feeders
4. Chemical Feed Tank Flow Rates
5. Coils
6. Condensate overflow safety switches
7. Differential Pressure Bypass Valves
8. Domestic Booster Pumps
9. Domestic Hot Water Heater Pumps
10. Domestic Re-circulating Systems and Water Heater
11. Elevator Pit Sump Pumps
12. Energy Recovery Ventilators
13. Flow Measuring Stations
14. Flow Meter Fittings
15. Flow Switches
16. Fluid Filter Housings
17. Freeze Protection Pumps
18. Geothermal U-Tubes, Circuits, and Headers
19. Geothermal Heat Pumps
20. Ground Heat Exchangers
21. Glycol Feed Pumps
22. High/Low Mixing Valves (Domestic Water)
23. Hydraulic Separators
24. In-line Pumps
25. Kitchen Ventilation Systems

26. Minimum Flow Bypass Valves.
27. Pumps
28. Rooftop Geothermal Heat Pump Units
29. System Mains and Branches
30. Thermostatic Mixing Valves
31. Water to Water Heat Pumps

1.2. ALTERNATES

A. Refer to Division 01 Section, Alternates for description of work under this section affected by alternates.

1.3. GENERAL COMMISSIONING REQUIREMENTS

A. Refer to Division 01 Section, “General Commissioning Requirements” for description of work under this Division affected by General Commissioning.

1.4. PRELIMINARY EXAMINATION

A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:

1. Systems are started and operating in a 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. 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. Fans are rotating correctly.
7. Fire dampers and volume dampers are in place and open.
8. Air coil fins are cleaned and combed.
9. Access doors are closed and duct end caps are in place.
10. Air outlets are installed and connected.
11. Duct system leakage is minimized.
12. Hydronic systems are flushed, filled, and vented.
13. Pumps are rotating correctly.
14. Proper strainer baskets are clean and in place.
15. Service and balance valves are open.

B. Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance.

C. Beginning of work means acceptance of exiting conditions.

1.5. QUALIFICATIONS OF THE BALANCE AGENCY

A. The balancing agency shall be a member of the Associated Air Balance Council (AABC).

B. The certified test and balance engineer shall be responsible for supervision and certification for the total work herein specified.

C. All final reports shall be signed by the certified test and balance engineer.

D. All personnel used on the project will be employees of an AABC Certified Agency. All work will be performed under the direct supervision of the AABC Certified Test and Balance Engineer (TBE). All work will be performed with AABC Certified Test and Balance Technicians (TBT) Resumes including education, experience, and certification of each person on the project shall be submitted.

E. Warranty. The AABC Agency shall submit a National Project Performance Guaranty.

1.6. PERSONNEL

A. All personnel used on the project will be employees of an AABC Certified Agency. All work will be performed under the direct supervision of the AABC Certified Test and Balance Engineer (TBE). All work will be performed with AABC Certified Test and Balance Technicians (TBT). Resumes including education, experience, and certification of each person on the project shall be submitted as informational submittals.

1.7. WARRANTY

A. The AABC Agency shall submit a National Project Performance Guaranty.

1.8. PRE-BALANCING CONFERENCE

A. Convene a conference one week prior to commencing work of this Section with all appropriate individuals.

1.9. STANDARDS

A. The balancing agency shall perform the services specified herein in accordance with the Associated Air Balance Council's National Standards, including revisions, to the date of the contract.

B. All terms in this specification shall have their meaning defined as stated in the National Standards.

C. ADC: Test Code for grilles, registers, and diffusers.

D. ASHRAE III: Practice for measurement, testing, adjusting and balancing of building heating, ventilation, air conditioning, and refrigeration systems.

E. NEBB: Procedure standards for testing, adjusting, and balancing of environmental systems.

F. SMACNA: HVAC systems testing, adjusting, and balancing.

G. AABC: Associated Air Balance Council

1.10. COORDINATION

A. It will be necessary for the balancing agency to perform its services in close coordination with the mechanical contractor.

B. The plans and specifications have indicated meters, valves, dampers, and other devices for the purpose of adjusting the system to obtain optimum operating conditions. It will be the responsibility of the mechanical contractor to install these devices in a manner that will leave them accessible and readily adjustable. The balancing agency shall provide guidance if there is a questionable arrangement of a control or balancing device.

C. The construction manager, mechanical contractor, temperature control contractor and suppliers of the HVAC equipment shall all cooperate with the balancing agency to provide all necessary data on the design and proper application of the system components.

D. For heat pumps, the manufacturer's start-up agency and Test and Balance Engineer shall assist each other with obtaining proper flow rates and refrigerant pressures.

1.11. INSTALLATION TOLERANCE

A. Unless otherwise indicated, all air devices shall be adjusted to within plus or minus 10 percent of design. All fans shall be adjusted to within plus or minus 5 percent of design. All pumps and Hydronic equipment shall be adjusted to within plus or minus 5 percent of design.

1.12. RESPONSIBILITIES OF THE TAB AGENCY

A. Liaison and Early Inspection. The following reviews, observations, and tests shall be performed by the TAB Agency:

1. Review the mechanical drawings and specifications for balanceability and provide commentary. Verify proper types and locations of all Test and Balance devices.
2. During construction, review all approved HVAC submittals such as control diagrams, air handling devices, hydronic devices, and other components that pertain to TAB work and balanceability. Assist the commissioning agent with all Functional Performance Testing.
3. Perform construction observations and submit a written report:

    a. On the ductwork prior to insulation and/or ceiling cover-up.
    b. On the piping prior to insulation and/or ceiling cover-up.

4. Witness duct pressure test as defined in the specifications, and submit a written report.
5. Perform a pre-balance site review, and submit a written report.
6. During the balancing process, abnormalities and malfunctions of equipment or components may be discovered by the TAB personnel. The Construction Inspector, Architect, Engineer, and Owner shall be advised in writing so that the condition(s) can be corrected by the Contractor. The written document need not be formal, but shall be understandable and legible. The TAB Agency shall not instruct or direct the Contractor in any of the work, but will make reports to the appropriate parties.

B. Final Air Balance. When systems are complete and ready for operation, the TAB Agency will perform a final air balance for all air systems and record the results. The volume of air for the supply, return, exhaust, and outside air equipment and terminals will be tested and balanced within the tolerances of the AABC Standard, or as specified, whichever is more stringent. Air handling unit and fan volumes shall be adjusted by changing fan speed. Air distribution device volumes shall be adjusted using the duct dampers and not the grille face. Air distribution devices shall be balanced with air patterns as specified. Duct volume dampers shall be adjusted to provide air volume to branch ducts where such dampers are shown. The general scope of balancing by the TAB Agency will include, but is not limited to, the following:

1. Filters: Check air filters and filter media. Balance systems with essentially clean filters and filter media.
2. Fan Speed: Measure and record RPM for each fan. Provide Controls Contractor with drive parameters for variable speed drives.
3. Voltage and Amperage Readings: Measure and record the final operating voltage and amperage for each motor.
4. Static Pressure Profile: Static pressure profiles shall be measured and recorded across each supply fan, cooling coil, heating coil, heat of rejection equipment fans, return air fan, air handling unit filter, exhaust fan, and at the furthest air device or terminal unit from the air handler supplying that device.
5. Equipment Air Flow: Adjust and record supply, return, outside and exhaust air CFM and temperatures, as applicable, at each fan and coil.
6. Coil and/or Heat Exchanger Temperatures: Set controls for full cooling and for full heating loads. Read and record entering and leaving dry bulb and wet bulb (cooling only) temperatures at each cooling coil, heating coil, and HVAC terminal unit. At the time of reading, record water flow and entering and leaving water temperatures and pressure drops. In variable flow systems, adjust the air and water flow to design for all the above readings.
7. Zone Air Flow: Adjust each HVAC terminal unit and each air-handling unit for design CFM.
8. Outlet Air Flow: Adjust each supply diffuser, register and grille, and each exhaust inlet to within the tolerance per the AABC Standard.
9. Pitot Tube Traverses: For use in future troubleshooting by maintenance personnel, all main supply, return, outside air, and exhaust ducts shall have air velocity and volume measured and recorded by the Pitot tube traverse method shown in the AABC Standard. Locations of these traverse test stations shall be described on the sheet containing the data. All Pitot tube traverses shall be clearly identified on the outside of the duct insulation with the traverse identified and duct size. Submit half scale drawings showing the locations of all duct traverses.

C. Final Water Balance. When systems are complete and ready for operation, the TAB Agency will perform a final water balance for each hydronic HVAC system. The general scope of balancing by the TAB Agency will include, but not be limited to, the following:

1. Adjusted System Tests: Adjust balancing valves at each coil and heat exchanger for design flow per the AABC Standard. Adjust balancing valves at pumps to obtain design water flow. Record pressure rise across pumps, and obtain GPM flow from the pump curve. Permanently mark the balanced position for each valve. If discharge valves on the pumps are used for balancing, record the head being restricted by the valves. Test and record autoflow valve differential pressures and adjust pump speed to optimize and minimize autflow differential pressure.
2. Temperature Readings: Read and record entering and leaving water temperature at

each water coil, converter, heat rejection equipment and heat exchanger at design flow. Adjust as necessary to secure design operating conditions. Provide final readings at all thermometer well locations.

3. Pressure Readings: Water pressure shall be recorded at all gauge connections. Pressure readings at coils and pumps shall be related to coil and pump curves in terms of GPM flow and through flow measuring stations, where provided and installed, at each hydronic unit. The flow of water through all water coils shall be adjusted by balancing valves until the rated pressure drop across each coil is obtained and total water flow is verified by flow measuring station. For coils equipped with three-way valves, the rated pressure drop shall first be adjusted through the coils. The bypass valve shall then be adjusted on each coil until the pressure drop between supply and return connections is the same as with the flow through the coil.
4. Voltage and Amperage Readings: Read and record the final operating voltage and amperage for each pump motor.
5. Pump Speed: Measure and record RPM for each pump. Provide Controls Contractor with drive parameters for variable speed pumps.

D. Testing of Temperature Control Systems as applicable to the project.

1. Air Handling Units

a. Start each air handling unit; verify and document:
- Dampers modulate properly and in the correct sequence.
- Fan(s) VFD ramps to design speed or proper controlled speed.
- All coil valves operate in response to the controlled temperature.
- All interlocked fans and/or devices energize.
- All alarms and safeties are operational and will alarm or shut down the unit.
- All operating scenarios are tested; e.g.: economizer cycle, minimum/maximum airflows, outside airflows at unit minimum/maximum volume, and special sequences.
- All end switches and positioners are properly set.
- All pressure controllers respond to increases or decreases in system pressure.
- All temperature and pressure sensors are calibrated.
- Airflow monitors report the correct airflow and control devices respond correctly to a change in airflow; e.g.: outside air control.
- Reset control sequences operate in response to changes in system temperatures, flows, or pressures.
- Correct operation of fan sequences when multiple fans are installed.
- Emergency mode operation; e.g.: power outage, freeze protection.
- Test all static pressure sensors and controls and calibrate the same.

b. Shut down each air handling unit; verify and document:
- Dampers respond properly (open, close, or modulate), and in the correct sequence.
- All fan systems ramp down and stop.
- Correct operation of fan sequences when multiple fans are installed.
- Emergency mode operation; e.g.: freeze protection.

- Interlocked devices turn off.
- System starts for setback temperature control.
- System starts on a temporary occupancy override.
- All coil valves go to their specified position.
- All alarms and safeties remain operational.

2. Fan Systems

a. Start each fan or fan system; verify and document:
- Interlocks and lockouts operate in accordance with the sequence.
- Fan(s) VFD ramps to design speed or proper controlled speed.
- All alarms and safeties are operational and will alarm or shut down the fan.
- Dampers modulate properly and in the correct sequence.
- All interlocked fans and/or devices energize.
- All end switches and positioners are properly set.
- All pressure controllers respond to increases or decreases in system pressure.
- All temperature and pressure sensors are calibrated.
- Airflow monitors report the correct airflow and that control devices respond correctly to a change in airflow; e.g.: outside air control.
- Correct operation of fan sequences when multiple fans are installed.
- Emergency mode operation; e.g.: power outage, freeze protection.

b. Shut down each fan or fan system; verify and document:
- Dampers respond properly (open, close, or modulate) and in the correct sequence.
- All fan systems ramp down and stop.
- Correct operation of fan sequences when multiple fans are installed.
- Interlocked devices turn off.
- All alarms and safeties remain operational.

3. Hydronic Systems

a. Start hydronic systems; verify and document:
- Valves modulate properly and in the correct sequence.
- Pump(s) VFD ramps to design speed or proper controlled speed.
- All isolation valves go to their "system on" position.
- All coil valves operate in response to the controlled temperature.
- All interlocked devices energize.
- All alarms and safeties are operational and will alarm or shut down the system.
- All operating scenarios are tested; e.g.: minimum/maximum water flows, minimum/maximum pressure, and special sequences.
- All end switches and positioners are properly set.
- All pressure controllers respond to increases or decreases in system pressure.
- All temperature and pressure sensors are calibrated.
- Flow meters report the correct water flow and that control devices

respond correctly to a change in water flow.

- Reset control sequences operate in response to changes in system temperatures, flows or pressures.
- Differential pressure across all autoflow valves, flow meters, PIC valves, coils, heat exchangers and equipment.
- Correct operation of pump sequences when multiples are installed.
- Emergency mode operation; e.g.: power outage, freeze protection.
- The controls have time delay strategy to avoid excessive cycling of pumps, and coils.

b. Shut down hydronic systems; verify and document:

- Valves modulate properly and in the correct sequence.
- Pump(s) VFD ramps down to off position.
- All isolation valves go to their "system off" position.
- All coil valves go to their normal off position.
- All interlocked devices de-energize.
- All alarms and safeties remain operational.
- Correct shutdown of pumps sequences when multiples are installed.
- Emergency mode operation; e.g.: freeze operation.

4. Component Calibration

All temperature, airflow, fluid flow, pressure, and flow measuring components shall be measured and compared to the control system readout; verify and document:

- The air temperature sensors for each coil, heat exchanger. If the temperature is not reading within tolerance, the sensor will be reported to the control contractor for calibration.
- The room temperature, relative humidity, and $C0_2$ sensors. If the sensors are not reading within tolerance, the sensors shall be reported to the control contractor for calibration.
- The water temperature sensors for each coil, heat exchanger. If the temperature is not reading within tolerance, the sensors shall be reported to the control contractor for calibration.
- All air and water pressure sensor readouts. If the pressure is not reading within tolerance, the sensor shall be reported to the control contractor for calibration.
- All flow measuring device readouts. If the flow readout is not recording within tolerance, the sensor shall be reported to the control contractor for calibration.

5. Point Verification

- Point verification for the digital control system documents that every point is operational and the setpoint, flow, temperature, or pressure is reporting correctly to the graphic interface. Verify and document all points.

6. Dynamic Testing

- Dynamic testing involves making a change of value at the sensor in order to observe the system's reaction and how it regains the original setpoint. Verify and document the system's response.

1.13. REPORTS

A. The report shall be a complete record of the HVAC system performance, including conditions of operation, items outstanding, and any deviations found during the process. The final report also provides a reference of actual operating conditions for the owner and/or operations personnel. The report summary is a project narrative describing the outcome of the testing and balancing and shall include a list of items that document all system variations deviating from design tolerances. Information can also be included that suggests possible resolutions.

B. All measurements and recorded readings that appear in the reports shall be certified by the Agency's Test and Balance Engineer.

C. Submit reports on forms approved by the Engineer. Hard and/or electronic copies of the final report shall be submitted in accordance with the Contract Requirements. The report shall indicate a summary of actual operating data and any abnormal operating conditions. The report shall contain all required information as described within this specification, including the information formatted and shown in the AABC Standard.

D. For phased projects, submit a final, complete, and comprehensive TAB report with index for all phases.

E. When the Engineer reviews TAB reports and provides comments, address each comment in writing for all re-submitted TAB reports.

1.14. TAB FINAL ACCEPTANCE INSPECTION

A. At the time of TAB final acceptance inspection, the TAB agency shall recheck, in the presence of the Owner's representative, specific and random selections of data recorded in the certified test and balance report.

B. Points and areas for recheck shall be selected by the Owner's representative.

C. Measurements shall be verified at the same test conditions as the submitted and approved test and balance agenda.

D. Selections for verification shall not exceed 10% of the total number tabulated in the report, except where special air systems require a complete recheck for safety reasons.

E. If 10% of the random verification tests demonstrate a measured flow deviation of 10%, or more from that recorded in the certified test and balance report, the report shall be automatically rejected. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, a new certified test and balance submitted, and a new inspection test made. There shall be no additional cost to the Owner for this work.

F. Final acceptance shall occur after successful completion of the TAB verification process.

1.15. RESPONSIBILITIES OF THE MECHANICAL CONTRACTOR

A. The mechanical contractor shall sufficiently complete the installation and start all HVAC and plumbing systems to insure they are working properly and shall perform all other items as described hereinafter to assist the balancing agency in performing the testing and balancing of the HVAC system.

B. Record equipment manufacturer's standard start-up information and submit to Engineer for review. Testing and balancing work shall not commence on any equipment until start-up reports have been completed, reviewed by Engineer, and forwarded to Testing and Balancing Agency.

C. The Contractor shall:

1. Have the building, air conditioning systems, heating systems, and plumbing systems in complete operational readiness for TAB work to begin.
2. The Contractor shall allow sufficient time for the TAB Agency to perform their contracted work within the construction schedule. The Contractor shall complete work by systems or floors, whichever is the most efficient for testing systems. After award of the contract and the completion of the construction schedule by the Contractor, a TAB coordination meeting shall be held with the TAB Agency, the Contractor and primary subcontractors, including but not limited to mechanical, electrical, and building automation subcontractors to develop a testing schedule for the project. The Contractor shall submit copies of the proposed schedule to the TAB Agency two weeks prior to this meeting.
3. Promptly correct deficiencies of materials and workmanship identified as delaying completion of TAB work.
4. Be responsible for any added costs to the Owner resulting from the Contractor's failure to have the building air conditioning systems and plumbing systems ready for TAB when scheduled, or from the Contractor's failure to correct deficiencies promptly.

D. Facility Operational Readiness

1. Complete operational readiness of the building requires that the building envelope be complete. This includes the installation of doors, windows, and ceilings to obtain simulated or projected operating conditions.

E. Air Distribution Systems

1. Verify installation for conformity to design.
2. Terminate all supply, return, outside air, exhaust air, relief air, ventilation air ducts, and pressure test them for leakage. Test pressure and leakage rate shall be as specified in Division 23 Section, HVAC Air Distribution System under Leakage Tests. Pressure testing shall be performed by mechanical contractor and witnessed by Test and Balance Engineer.
3. Ensure that all volume dampers, fire dampers, and smoke damper are properly located and functional. Dampers serving requirements of minimum and maximum outside - return - relief, and exhaust air shall provide tight closure and full opening, with a smooth and free operation.
4. Verify that all supply - return - exhaust and transfer grilles; registers, and diffusers

are installed, operational, and sealed tightly.

5. Ensure that air-handling systems, units, and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., are blanked and/or sealed to eliminate excessive bypass or leakage of air.
6. Ensure that all fans are operating and free of vibration. All fans and drives shall be checked for proper fan rotation and belt tension. Overload protection shall be of proper size and rating. A record of motor current and voltage shall be made to verify that the motors do not exceed nameplate rating. Record thermal overload ratings for all motors in the Test and Balance Report.
7. Make any necessary changes to the sheaves, belts, and dampers, as required by the balancing agency, at no additional cost to the owner.
8. Install clean filters.
9. Coils shall be clean with fins straightened, bearings shall be properly greased, belts shall be aligned and tightened, and the system shall be completely operational. The Contractor shall verify that all systems are operating within the design pressure limits of the piping and ductwork.
10. All supply, return, exhaust, and relief fans shall be operating and verified for: freedom from vibration, proper fan rotation and belt tension; heater elements in motor starters to be of proper size and rating, as the as per the starter manufacturer. Record motor amperage and voltage on each phase at start-up, verifying they do not exceed nameplate ratings.
11. For heat pumps, provide refrigerant suction and discharge pressure to Test and Balance Engineer for inclusion in the final TAB Report.

F. Water Circulating Systems

1. Verify installation for conformity to design.
2. Check all pumps to verify pump alignment and rotation.
3. Ensure that systems are clean, with the proper strainer screens installed for normal operation.
4. Check all pump motors for current on each phase and voltage, to ensure that motors do not exceed nameplate rating.
5. Provide thermal overload protection of proper size per the starter manufacturer and rating. Record thermal overload ratings for all motors. Insert data in Test and Balance Report.
6. Ensure that all water circulating systems shall be full and free of air; that expansion tanks are set for proper water level; and that all air vents were installed at high points of systems and are operating.
7. All piping shall be terminated and pressure tested for leakage as required by the specification. All valves shall be set to their full open position, bypass stop valves shall be closed, and mixing valves shall be set to full-flow through the the system's components. After the system is flushed and checked for proper operation, all strainers shall be removed and cleaned. The Contractor shall repeat the operation until circulating water is clean. The start-up strainers shall then be removed and hung adjacent to the pumps.
8. Chemicals shall be added to closed systems to treat piping and inhibit corrosion. The system static pressure shall be adequate to completely fill the system without operating the pumps.
9. The operating parameters of the heat exchangers, coils, pumps, and control devices shall be capable of obtaining design requirements.
10. Proper balancing devices shall be installed in the designated locations. These

devices include but are not limited to flow meters, pressure taps, thermometer wells, and balancing valves.

G. Notification of System Readiness

1. After completion of the work, the Contractor shall notify the Owner and TAB Agency, in writing, certifying that the work has been accomplished and that the building, air conditioning, and plumbing systems are ready for testing, adjusting, and balancing. The Contractor shall include a copy of the tabulated data of the start-up reports.
2. The Contractor shall notify the TAB Agency of the readiness for balancing and forward copies of the Contractor's certification and the tabulated data.
3. Should the TAB Agency be notified as described above and the inspection reveal the TAB services notification to have been premature, all costs of the inspection by the TAB Agency shall be reimbursed by the Contractor.

1.16. CONTRACTOR SUPPLIED ITEMS

A. As a requirement of the TAB contract, the Contractor's Project Manager shall compile and provide the TAB Agency the following:

1. One set of mechanical specifications.
2. All pertinent change orders.
3. All Request(s) for Information (RFI).
4. One complete set of MEP Drawings.
5. One copy of approved submittal data on equipment installed and controls submittal with sequences of operation.
6. All HVAC Control Communications software with the appropriate licenses and hardware interfaces.

1.17. RESPONSIBILITIES OF THE TEMPERATURE CONTROL CONTRACTOR

A. The temperature control contractor shall complete the installation of the temperature control system, and operate and test all control systems to ensure they are functioning properly as designed. The temperature control contractor shall assist the balancing agency in testing and balancing the HVAC systems, as described hereinafter.

1. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water reset, freeze stats, high and low temperature thermostats, safeties, and duct smoke detectors.
2. Verify that all controlling instruments are calibrated and set for design operating conditions.
3. Calibrate temperature sensors after installation, and before the temperature sensors control verification tests are performed. The balancing agency shall prove the accuracy of final settings by taking temperature readings. The readings shall be in a typical conditional space for each separately controlled zone.
4. The temperature control contractor shall allow sufficient time in the project to provide assistance and instruction to the balancing agency in the proper use and setting of control components such as, but not limited to, computers, static pressure controllers, or any other device that may need set points changed so that the testing

and balancing work can be performed.

5. The Control Contractor shall schedule a meeting with the Mechanical Contractor, TAB Agency, and Owner's representative for a pre-submittal review to establish that their interpretation of the control sequence is correct.
6. The Control Contractor shall verify that all controlling instruments are calibrated and set for design operating conditions, with the exception of components that require input from the TAB Agency. A default shall be set for such components. The Control Contractor shall cooperate with the TAB Agency and provide all software and interfaces necessary to communicate with the system.
7. The Automatic Temperature Control Contractor shall thoroughly check all controls, sensors, operators, and sequences before notifying the TAB Agency that the Energy Management System is operational. The Energy Management System Contractor shall provide technical support in the form of technicians and necessary computers to the TAB Agency for a complete check of those systems.
8. The Fire Alarm (FA) Contractor shall thoroughly check all detection devices, sequences, interlocks, and other components before notifying the TAB Agency that the system is operational, including the Fireman's Override Panel. The FA Contractor shall provide all documentation that identifies all fire and smoke detection devices, all smoke zones, and all alarm and event chart devices. The FA Contractor shall certify to the Contractor that the systems are totally operational prior to the start of TAB.

B. All control sequences, software, equipment, and components shall be started-up by a qualified technician. Start-up report shall be submitted to Engineer prior to the commencement of testing and balancing work. Testing and balancing shall not commence until start-up reports are completed, reviewed by Engineer and forwarded to Testing and Balancing Agency.

1.18. NOTIFICATION FOR TESTING AND BALANCING WORK TO BEGIN

A. The mechanical contractor shall notify the balancing agency in writing when all heating, ventilating, and air conditioning and plumbing systems are complete and ready for testing and balancing. The mechanical contractor shall attest that he has completed all items as herein described.

B. The following must be completed prior to start of system balancing:

1. All duct work and associated grilles/registers/diffusers installed and completed.
2. Piping systems completed, flushed and filled.
3. Equipment properly started by qualified personnel or start-up technicians.
4. Ceiling tiles installed.
5. Automation system (temperature controls) installed and completed for both air and water systems.
6. All equipment controlled in automatic ("Auto") mode.
7. Access granted to the balancing contractor to the automation/controls system provided.

C. Mechanical Contractor shall notify the Construction Manager of the start date of this portion of the work.

1.19. DEFICIENCIES

A. Any deficiencies in the installation or performance of a system or component observed by the TAB agency shall be brought to the attention of the appropriate responsible person.

B. The work necessary to correct items on the deficiency listing shall be performed and verified by the affected Contractor before the TAB Agency returns to retest. Unresolved deficiencies shall be noted in the final report.

C. TAB Agency shall notify Construction Manager of all deficiencies found during initial survey.

1.20. ADJUSTING

A. Ensure recorded data represents actual measured observed conditions.

B. Permanently mark 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 all sensors to specified settings.

E. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

F. Check and adjust systems approximately six months after final acceptance and submit report.

G. Permanently mark the locations of all duct traverses on the exterior surface of the duct insulation. For exterior ductwork, the duct traverse locations must be identified with waterproof labels.

PART 2. PRODUCTS (NOT APPLICABLE)

PART 3. EXECUTION

3.1. GENERAL

A. Perform all testing and balancing in complete accordance with AABC National Standards for Field Measurements and Instrumentation.

B. Furnish all test instruments and equipment. All instruments must have been calibrated within twelve (12) months prior to use and shall be checked for accuracy prior to and during the work. Submit certificate for calibration of all equipment utilized on project with date of calibration clearly identified.

C. Review all systems designs and equipment, manufacturers' data, and be completely familiar with the work before proceeding.

D. Report all malfunctions or deficiencies to the contractor so that corrective action can be taken. Test and Balance Report shall not be submitted for review until all malfunctions or deficiencies are corrected. Repeat tests where required until design conditions are achieved.

E. Where systems or equipment cannot be balanced or adjusted to design conditions, determine the cause and submit a complete report to the Engineer.

F. Retest or rebalance the system as required during the warranty period.

G. Test and balance all systems under adequate load condition. If, in the opinion of the Engineer, there is insufficient load to properly test and balance the systems, perform sufficient preliminary balancing and adjustment to permit operation of the systems until such time as final testing and balancing can be done. Provide in writing the future date when systems shall be tested under sufficient load.

H. At project completion provide a complete set of ½ scale drawings indicating the locations of all duct traverses.

3.2. EXAMINATION

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

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

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

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC/plumbing system and equipment controls.

E. Examine ceiling plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems – Duct Design". Compare results with the design data and installed conditions.

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

H. Examine test reports specified in individual system and equipment Sections.

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

J. Examine terminal units, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens and indicated perforations.

L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

M. Examine system pumps to ensure absence of entrained air in the suction piping.

N. Examine operating safety interlocks and controls on HVAC equipment.

O. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.3. AIR SYSTEM PROCEDURES

A. The balancing agency shall perform the following testing and balancing functions in accordance with the Associated Air Balance Council's National Standards:

1. Fan Speeds - Test and adjust fan RPM to achieve design CFM requirements.
2. Current and Voltage - Measure and record motor current and voltage. Check and record thermal overload ratings for all motors.
3. Pitot-Tube Traverse - Perform a Pitot-tube traverse of main supply, return and exhaust ducts to obtain total CFM. If a Pitot-tube traverse is not practical, the summation of the outlets or inlets may be used. An explanation why a traverse was not made must appear on the appropriate data sheet.
4. Outside Air - Test and adjust system minimum outside air by Pitot-tube traverse. If a Pitot-tube traverse is not practical, the percentage of outside air may be determined by calculations from the return air, outside air, and mixed air temperatures. Make allowances for heat of compression and motor heat where applicable.
5. Static Pressure - Test and record system static pressures, including suction and discharge static pressure of each fan. Record hood static pressure at kitchen hood exhaust taps, kiln hoods, canopy hoods, fume hoods and similar equipment. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make fan RPM allowances for 50 percent loading of filters.
6. Air Temperature - Take wet-bulb and dry-bulb air temperatures on the entering and leaving side of each cooling coil and/or heat recovery coil. Dry-bulb temperature shall be taken on the entering and leaving side of each heating coil.
7. Zone Ducts - Adjust zone ducts to within design CFM requirements. At least one

zone balancing damper shall be completely open.

8. Main Ducts - Adjust main ducts to within design CFM requirements and traverse for total CFM quantities.
9. Branch Ducts - Adjust branch ducts to within design CFM requirements. Multi-diffuser branch ducts shall have at least one outlet or inlet volume damper completely open.
10. Magnahelic Gauges - Static pressure at static pressure tips for Magnahelic gauges shall be recorded in Test and Balance Reports.
11. Tolerances - Test and balance each diffuser, grille, and register to within 10 percent of design requirements. Test and balance all fans to within 5 percent of design requirements.
12. Identification - Identify the location and area of each grille, diffuser, and register. This information shall be recorded on air outlet data sheets.
13. Description - Record the size, type, and manufacturer of each diffuser, grille, and register on air outlet data sheets.
14. Minimizing Drafts - Adjust all diffusers, grilles, and registers to minimize drafts in all areas.
15. Test and Balance Engineer shall witness and record all leakage testing of ductwork. Leakage test data shall be included in final Test and Balance Reports.
16. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable air volume systems at maximum air flow rate, full cooling, and at minimum airflow rate, full heating.
17. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
18. For heat pumps assist start-up organization or manufacturer's representative with start-up. Record air flow rates, water flow rates and electrical characteristics prior to refrigerant pressure measurement and settings.
19. For all equipment specified with condensate overflow safety switches/floats test operation of such device and record results. Verify interlock with ATC system.
20. Outside air and exhaust/relief air measurements must be measured and submitted in all modes of operation including the following:

    a. Min Min Outside Air/Exhaust/Relief air mode (square footage outside air).
    b. Min Max Outside Air/Exhaust/Relief air mode (square footage and people outside air).
    c. Maximum outside air/exhaust/relief mode (full 100% economizer mode).

21. For all outside air modes of operation record and submit full static pressure profiles, amperage, BHP, air flow rates, external static pressure, and internal static pressure. Verify airflow rates with air flow monitoring stations and record results.

3.4. WATER SYSTEM PROCEDURES

A. The various water circulating systems shall be filled, purged of air, and put into operation before hydronic balancing by the mechanical contractor.

B. The flow of water through all coils shall be adjusted by manipulating balancing valves until the rated pressure drop through the coil or metering device is obtained. Perform balancing by measurement of temperature differential in conjunction with air balancing.

C. The balancing agency shall perform the following testing and balancing functions in accordance with the AABC National Standards.

D. All Hydronic equipment, domestic re-circulating pumps, and HVAC pumps shall be Tested and Balanced as described below:

1. Water Treatment - Examine the water in the system and determine if the water has been treated and cleaned. If it has not, request the mechanical contractor to clean and treat the water prior to TAB work
2. Strainers - Request that the mechanical contractor clean all strainers.
3. Air Vents - Check all air vents at the high points of the water system and determine if they are installed and operating.
4. Valves - Set all balancing valves to the full-open position for balancing.
5. Pumps - Adjust all pumps and domestic hot water re-circulating water pumps to meet design GPM requirements. Check pumps for proper operation. Pumps shall be free of vibration and cavitation. Measure and record operating current and voltage. Check and record thermal overloads installed on all pumps. Record in Test and Balance Report.
6. Tolerances - Proceed to balance all coils, pumps, balance valves heat exchangers, and vertical u-tubes to within 5 percent of design requirements.
7. Marking - Mark all settings and record all data after completing the flow readings and coil adjustments.
8. Where available pump capacity (due to diversity) is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.
9. Test and verify proper operation of oil sensors at elevator pit sump pump and report results.
10. Test all A/C condensate pumps for proper operation.
11. Test condensate overflow safety switches.

E. Geothermal Heat Pump Test Forms - Record the following items on each geothermal heat pump test form:

1. Manufacturer model number, serial numbers.
2. All design and manufacturer's rated data.
3. Service and location.
4. Actual pressure drop and design pressure drop of condenser/evaporator coils.
5. Entering and leaving water fluid of condenser/evaporator coils.
6. Temperature control settings.
7. Electrical characteristics.
8. Where applicable, test hot gas re-heat coil and record temperatures entering and leaving unit.

F. Exterior Geothermal Heat Pump U-Tube Test Form:

1. Entering temperature, design and actual.
2. Leaving temperature, design and actual.
3. Water flow, design and actual.
4. Water pressure drop, design and actual.

G. Coils:

1. Tolerances - Test, adjust, and balance all hydronic coils within 5 percent of design requirements.
2. Verification - Verify the type, location, final pressure drop and GPM of each coil. This information shall be recorded on coil data sheets.

3.5. DOMESTIC HOT WATER RE-CIRCULATING SYSTEMS PROCEDURES

A. The domestic hot water re-circulating system shall be tested and balanced as indicated on the contract documents including:

1. Balance of circuit setters to design quantities indicated on contract documents.
2. Balance of re-circulating pumps to meet design GPM requirements.

B. Domestic Water Heaters:

1. Verify that all domestic water heaters have been filled and started by others and are in operation. Where heat pump water heaters are specified, test in electric only mode, heat pump mode, and simultaneous mode.
2. Test and record outlet temperature of water heater at approximate design recovery.
3. Current and Voltage: As applicable, test and record voltage and amperage, compare data with nameplate limits to ensure water heater elements or burners do not exceed nameplate data.
4. Test discharge temperature and flow rate at all lavatory/hand sink mixing valves. Also measure time period for fixtures to obtain hot water.

3.6. KITCHEN HOOD TESTING AND BALANCING PROCEDURES

A. The kitchen hood exhaust and make-up air quantities shall be tested and balanced to the indicated design quantities (CFM). The air flow of each shall be determined by the use of pitot tube traverse and/or a short ridge velgrid.

B. The kitchen hood should then be tested for adequate capture using a 30 second smoke bomb. The cooking equipment below the hood should be turned on and brought up to normal operating temperature. All grease filters should be in place. The kitchen make-up air unit and exhaust fans shall be on. The hood static pressure should be recorded and documented in the Test and Balance Report and the hood shall be tested and must provide 100 percent capture. If the hood does not prove 100 percent capture, the source of the problem shall be determined and the test repeated. Record results of tests within TAB report.

3.7. FIRE AND SMOKE TESTING PROCEDURES

A. The TAB agency shall test fire/smoke damper to assure operation. It shall verify that an access door has been installed for each fire and smoke damper. For fire dampers, the TAB agency shall open the access door, disconnect the fusible link, and allow the damper to close. Operation should be smooth and the damper must close completely. The TAB agency shall then reset the damper. For the smoke damper, the TAB agency shall open the access door, activate the damper, and observe operation. The damper must close quickly and completely. The TAB agency shall then reset the damper and observe its complete opening. Record results of tests within TAB report.

3.8. LIFE SAFETY CONTROLS TESTING PROCEDURES

A. The TAB agency shall test and record life safety control operation on the HVAC equipment. It shall verify the installation of required smoke detectors in air handling equipment (AHE), and shall verify operation of the smoke detector by activating the smoke detector and observing air handler shutdown. With the controls and alarm contractors, the TAB agency shall verify the operation of interconnected systems such as the AHU smoke detector's activation of the fire alarm system and the alarm system's activation of the life safety control sequences. Record results of tests within TAB report.

3.9. VERIFICATION OF TEMPERATURE CONTROL

A. The balancing agency shall be assisted by the temperature control contractor in verifying the operation and calibration of all temperature control systems. The following tests shall be conducted:

1. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water reset.
2. Verify that all controlling instruments are calibrated and set for design operating conditions.
3. Verify the accuracy of the final settings by taking temperature readings. The readings shall be in a typical conditioned space for each separately controlled zone.
4. Test and calibrate all air flow monitoring stations for proper air flow.
5. Test and calibrate all static pressure sensors for proper set point and control.
6. Test and calibrate all differential pressure sensors. Record set point in Record and Information Books.

3.10. TEST AND BALANCE REPORTS

A. The test and balance report shall be complete with logs, data, and records as required herein. All logs, data, and records shall be typed on white bond paper and bound. The report shall be certified accurate and complete by the balancing agency's certified test and balance engineer.

B. Six (6) hardcopies and one (1) electronic copy of the test and balance report are required and shall be submitted to the Engineer. If, in the opinion of the Engineer, test results or portions thereof are incomplete or inconclusive, repeat necessary portions of the work to the satisfaction of the Engineer.

C. The report shall contain the following general data in a format selected by the balancing agency:

1. Project Number
2. Contract Number
3. Project Title
4. Project Location
5. Project Architect
6. Project Mechanical Engineer
7. Test & Balance Agency
8. Test & Balance Engineer

9. Construction Manager
10. Mechanical Contractor
11. Commissioning Agent
12. Dates tests were performed
13. Certification
14. Duct Leakage Tests
15. Phone Numbers of all Individuals Listed Above

D. The test and balance report shall be recorded on report forms conforming to the recommended forms in the AABC National Standards.

E. The test and balance report shall include a table of contents with numbered pages.

3.11. TEST REPORT FORMS

A. Air Moving Equipment and Fan Test Forms - Submit fan curve showing design and operating points of operation. Also, record the following on each air-handling and geothermal heat pump equipment test form:

1. Manufacturer, model number, serial number, arrangement.
2. All design and manufacturer-rated data.
3. Total actual CFM by traverse if practical. If not practical, the sum of the outlets may be used, or a combination of each of these procedures. For specific systems, such as ones with diversity, see the AABC National Standards.
4. Suction and discharge static pressure of each fan, as applicable. Include pressure drops across coils, dampers, filters, mixing boxes, and similar devices.
5. Outside-air, return-air, and exhaust air total CFM.
6. Actual operating current, voltage and brake horsepower of each fan motor. For packaged equipment, this includes supply fans, relief air fans, and condenser fans.
7. Final RPM of each fan.
8. Fan and motor sheave manufacturer, model, size, number of grooves, bore, and center distance.
9. Belt size, quantity and make.
10. Static-pressure controls final operating set points (if applicable).
11. Total and external static pressure.

B. Pump Test Forms - Submit pump curve showing design, operating, and no-flow points of operation. Also, record the following items on each pump test form:

1. Manufacturer, size, model, service and serial number.
2. All design and manufacturer's rated data.
3. Pump operating suction and discharge pressure and final total dynamic head.
4. No flow (pump discharge valve closed) suction and discharge pressure and corresponding total dynamic head. This procedure is to determine actual impeller size. Record impeller size.
5. Rated and actual operating current, voltage, and brake horsepower of each pump motor.
6. Total operating head pressure.
7. Shutoff, discharge and suction pressures.
8. Shutoff, total head pressure.

C. Heating and Cooling-Coil Test Forms - Record the following items on each test form:

1. Manufacturer, location, service.
2. All design and manufacturer's rated data.
3. Rated and actual water pressure drop through each coil and related GPM.
4. Rated and actual static pressure drop across each coil.
5. Rated and actual entering and leaving water temperatures across each coil.
6. Wet-bulb and dry-bulb temperatures entering and leaving each cooling coil; dry-bulb temperatures entering and leaving each heating coil.
7. Air flow (Design and Actual).
8. For DX-coil, provide design and actual saturated suction temperature.
9. For DX-Coil, provide design and actual discharge pressures.

D. Airflow Monitoring Station Test Forms:

1. Identification /location.
2. Manufacturer.
3. Systems.
4. Size and Model Number.
5. Area.
6. Design Velocity.
7. Design Airflow.
8. Test Velocity.
9. Test Airflow.
10. Static Pressure Drop and Velocity Pressure.
11. Station Calibrated Setting.

E. Flow Measuring Station Test Forms:

1. Identification/location.
2. Manufacturer.
3. Size and Model Number.
4. Design and Actual Flow Rate.
5. Design and Actual Pressure Drop.
6. ATC flow rate versus field measured flow rate.

F. Electric Unit Heater Test Forms:

1. Manufacturer.
2. Identification/number.
3. Location.
4. Model number.
5. Design kW and actual kW.
6. Phase, voltage, amperage.
7. Test voltage (each phase).
8. Test amperage (each phase).
9. Air flow, specified and actual.
10. Temperature rise, specified and actual.

G. Electric Motors Test Forms: (Applies to all motors, including pumps, fans and HVAC equipment)

1. Manufacturer.
2. Model/Frame.
3. HP/BHP.
4. Phase, voltage, amperage; nameplate, actual, no load.
5. RPM.
6. Service factor.
7. Starter size, rating, heater elements.
8. Sheave Make/Size/Bore.
9. Thermal overload settings

H. V-Belt Drive Test Forms:

1. Identification/location.
2. Required driven RPM.
3. Driven sheave, diameter and RPM.
4. Belt, size and quantity.
5. Motor sheave diameter and RPM.
6. Center to center distance, maximum, minimum, and actual.

I. Duct Traverse Test Forms:

1. System zone/branch.
2. Duct size.
3. Area.
4. Design velocity.
5. Design air flow.
6. Test velocity.
7. Test airflow.
8. Duct static pressure.
9. Air temperature.
10. Air correction factor.

J. Duct Leakage Test Forms:

1. Description of ductwork under test.
2. Duct design operating pressure.
3. Duct design test static pressure.
4. Duct capacity, air flow.
5. Maximum allowable leakage duct capacity times leak factor.
6. Test apparatus.
   a. Blower.
   b. Orifice, tube size.
   c. Orifice size.
   d. Calibrated.
7. Test static pressure.
8. Test orifice differential pressure.
9. Leakage.

K. Air Distribution Test Forms:

1. Air terminal number.
2. Room number/location.
3. Terminal type.
4. Terminal size.
5. Area factor.
6. Design velocity.
7. Design air flow.
8. Test (final) velocity.
9. Test (final) air flow.
10. Percent of design air flow.

L. Ductless Unit Test Forms:

1. Manufacturer
2. Type, air conditioning, heat pump
3. Identification number
4. Location
5. All design and manufacturer's rated data.
6. Rated and actual entering and leaving dry bulb temperatures.
7. Rated and actual entering and leaving wet bulb temperatures.
8. Air flow (design and actual)
9. Provide actual saturated suction temperature.
10. Actual operating current, voltage and brake horsepower of each fan motor.
11. Final fan RPM.

M. Energy Recovery Ventilators Test Forms: Submit fan curve showing design and operating points of operation. Also, record the following on each air-handling equipment test form:

1. Manufacturer, model number, serial number, arrangement.
2. All design and manufacturer-rated data.
3. Total actual CFM by traverse if practical. If not practical, the sum of the outlets may be used, or a combination of each of these procedures. For specific systems, such as ones with diversity, see the AABC National Standards.
4. Suction and discharge static pressure of each fan, as applicable. Include pressure drops across coils, filters, energy wheels, and similar devices.
5. Outside-air, and exhaust air total CFM.
6. Actual operating current, voltage and brake horsepower of each fan motor.
7. Final RPM of each fan.
8. Fan and motor sheave manufacturer, model, size, number of grooves, bore, and center distance.
9. Belt size, quantity and make.
10. Total and external static pressure.
11. Rated and actual static pressure drop across each energy wheel.
12. Wet-bulb and dry-bulb temperatures entering and leaving each cooling coil, heat pipe and energy wheel. Dry-bulb temperatures entering and leaving each heating coil.
13. Rated and actual entering and leaving pressure at each hydronic coil.
14. For DX-coil, provide design and actual saturated suction temperature.
15. Record carbon dioxide set points and actual readings for exhaust air stream at each ERV and global CO2 sensor.
16. Entering and leaving air temperatures at hot gas re-heat coils.

17. Record the supply fan and exhaust fan maximum hertz/speed and minimum hertz/speed. Provide measurements to ATC subcontractor for fan tracking control.
18. Test minimum air flow rate and maximum air flow rate. Submit amperage, air flow rates, RPM, hertz, and static pressure profile in all modes of operation.

N. Geothermal Water to Water Heat Pump Test Forms - Record the following items on each heat pump test form:

1. Manufacturer model number, serial numbers.
2. All design and manufacturer's rated data.
3. Service and location.
4. Design and actual pressure drop, related GPM, source side.
5. Design and actual pressure drop, related GPM, load side.
6. Source side entering and leaving temperatures, design and actual.
7. Load side entering and leaving temperatures, design and actual.
8. Temperature control settings.
9. Electrical characteristics, design and actual.
10. Suction pressure (provided by start-up agency).
11. Discharge pressure (provided by start-up agency).

O. Ground Heat Exchanger Test Forms:

1. Entering temperature, design and actual.
2. Leaving temperature, design and actual.
3. Primary water flow, design and actual.
4. Primary water pressure drop, design and actual.

P. Water to Air Heat Pump Test Forms – Record the Following Items on Each Heat Pump Test Form:

1. Manufacturer model number, serial numbers.
2. All design and manufacturer’s rated data.
3. Design and actual fluid pressure and related GPM.
4. Ground loop entering and leaving temperatures, design and actual.
5. Electrical characteristics, design, and actual.
6. Suction pressure (provided by start-up agency).
7. Discharge pressure (provided by start-up agency).
8. Fan speed, static pressure voltage, amp draw.
9. Wet Bulb and dry Bulb temperatures entering, leaving coil design, actual.
10. For units with hot gas re-heat, entering/leaving temperatures at hot gas coil.

Q. Kitchen Make-up Air Unit Test Forms

1. Manufacturer model number, serial numbers.
2. All design and manufacturer’s rated data.
3. Design and actual fluid pressure and related GPM.
4. Electrical characteristics, design, and actual.
5. Fan speed, static pressure voltage, amp draw.
6. Wet Bulb and dry Bulb temperatures entering, leaving coils design, actual.
7. Air flow rate/RPM at maximum flow and minimum flow.
8. Interlocked exhaust fan air flow rate/RPM at maximum flow and minimum flow.

9. Temperatures entering and leaving the heat pipe, design, and actual.
10. Where applicable entering/leaving temperatures at evaporator coils, hot gas re-heat coils, design, and actual.
11. Record the supply fan and exhaust fan maximum hertz/speed and minimum hertz/speed. Provide measurements to ATC subcontractor for fan tracking control.

R. Elevator Sump Pump Test Forms:

1. Manufacturer, Model Number, and Serial Number.
2. Motor Horsepower – Design/Actual
3. Voltage/Phase/Hz/Amps
4. Verify ATC interlocks.
5. Test high water condition.

S. Air Cooled Heat Pump Test Forms:

1. Manufacturer
2. Model Number
3. Location
4. Size/Capacity
5. Fan RPM (Min and Max)
6. Compressor and Condenser/Heat Pump Fan Electrical Characteristics
7. Condenser/Heat Pump Fan RPM
8. Amp Draw of all Components
9. Refrigerant Suction/Discharge Pressures
10. Thermal Overload Sizes

T. High/Low Mixing Valve Test Forms

1. Manufacturer, Model Number, Series, Arrangement
2. All manufacturer data.
3. Verify all strainers are clean.
4. Leaving temperature actual and design.

U. Thermostatic Mixing Valve Test Forms

1. Manufacturer, Model Number, Series, Arrangement
2. All manufacturer data.
3. Verify all strainers are clean.
4. Leaving temperature actual and design.

V. Water Heater Test Forms

1. Manufacturer, Model Number, Series
2. All manufacturers' data.
3. Verify all safeties.
4. Record leaving water temperature actual and design.
5. Verify operation in all modes of operation.
6. Verify combustion air damper interlock.
7. Record electrical characteristics

W. Condensate Over Flow Switches/Floats Test Forms

1. Manufacturer
2. Type
3. Location
4. Equipment shut down verification
5. ATC interlock verification

X. Electric Radiant Heat Panels Test Forms:

1. Manufacturer.
2. Identification/number.
3. Location.
4. Model number.
5. Design kW and actual kW.
6. Phase, voltage, amperage.
7. Test voltage (each phase).
8. Test amperage (each phase).
9. Air flow, specified and actual.
10. Temperature rise, specified and actual.

Y. Packaged Automatic Glycol Feeder Test Forms:

1. Manufacturer, model number, serial number.
2. All design and actual measured data.
3. Pump discharge pressure.
4. Rated and actual voltage, current.
5. Pressure switch set point pressure.
6. Test all safeties and alarms.

Z. Geothermal Rooftop Unit Test Forms: Submit fan curve showing design and operating points of operation. Also, record the following on each air-handling equipment test form:

1. Manufacturer, model number, serial number, arrangement.
2. All design and manufacturer-rated data.
3. Total actual CFM by traverse if practical. If not practical, the sum of the outlets may be used, or a combination of each of these procedures. For specific systems, such as ones with diversity, see the AABC National Standards.
4. Suction and discharge static pressure of each fan, as applicable. Include pressure drops across coils, filters, and similar devices.
5. Outside-air, and exhaust air total CFM.
6. Actual operating current, voltage and brake horsepower of each fan motor.
7. Final RPM of each fan.
8. Fan and motor sheave manufacturer, model, size, number of grooves, bore, and center distance.
9. Belt size, quantity and make.
10. Total and external static pressure.
11. Wet-bulb and dry-bulb temperatures entering and leaving each cooling coil. Dry-bulb temperatures entering and leaving each gas furnace.
12. For DX-coil, provide design and actual saturated suction temperature.
13. Record the supply fan and exhaust fan maximum hertz/speed, and minimum

hertz/speed.

14. Test minimum outside air flow rate, maximum outside air flow rate, relief air flow rate, and economizer air flow rate.
15. Test hot gas re-heat coils and record temperatures and pressure drops.
16. Test and record differential static pressure and operate relief air damper.

AA. Kitchen Hood Test Forms:

1. Manufacturer.
2. Identification/type of hood.
3. Location.
4. Total exhaust air flow rate in CFM.
5. Exhaust duct traverse size and location.
6. Filter face velocities.
7. Exhaust duct static pressure in inches w.g.
8. Results of smoke testing.
9. Total make-up air unit airflow rate in CFM.

BB. Dryer Duct Booster Fans Test Forms:

1. Manufacture, model number and serial number.
2. All design data.
3. Total actual CFM by Traverse.
4. Suction and discharge static pressure of each fan.
5. Actual operating voltage and brake horsepower of each fan motor.
6. Final RPM of each fan.
7. External and total static pressure.
8. Dryer duct booster fan setpoint.

END OF SECTION

DIVISION 23 SECTION 23 06 00
HEATING, VENTILATING, AND AIR CONDITIONING EQUIPMENT
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SECTION 23 06 00 – HEATING, VENTILATING, AND AIR CONDITIONING EQUIPMENT

PART 1. GENERAL

1.1. GENERAL

A. The Conditions of the Contract and other General Requirements apply to the work specified in this section. All work under this section shall also be subject to the requirements of Division 23 Section, Common Work Results for HVAC and Division 01 Section General Requirements.

1.2. DESCRIPTION

A. The work to be performed shall include all labor, materials and equipment necessary to furnish and install complete, all mechanical equipment as shown on drawings, hereinafter specified or reasonably implied, and leaving the same in satisfactory operation condition. It is the intent that systems be installed complete with all items necessary to accomplish this purpose.

1.3. SUBMITTALS

A. Shop Drawings: Indicate assembly, equipment dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.

B. Product Data:

1. Provide literature which indicates dimensions, weights, capacities, ratings, performance, gages and finishes of materials, and electrical characteristics and connection requirements.
2. Provide data of filter media, filter performance data, filter assembly, and filters frames.
3. Provide fan and pump curves with specified operating point clearly plotted.
4. Submit sound power level data for both fan outlet and casing radiation at rated capacity. Submit sound power levels by octave band or sound pressure levels by octave band for all equipment.
5. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

1.4. OPERATION AND MAINTENANCE DATA

A. Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.5. DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect, and handle products to site under provisions of General Requirements.

B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.

C. Store all equipment in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

D. Comply with manufacturer's installation instructions for rigging, unloading and transporting equipment.

E. Protect all motors, shafts, and bearings from weather and construction dust.

1.6. ENVIRONMENTAL REQUIREMENTS

A. Do not operate any equipment for any purpose, temporary or permanent, until ductwork/piping is clean, filters/strainers are in place, bearings lubricated, and equipment has been test run under observation.

1.7. ALTERNATES

A. Refer to Division 01 Section, “Alternates” for description of work under this section affected by alternates.

1.8. EXTRA MATERIALS

A. Provide one set of seals for each type and model of pump provided on the project.

1.9. SHORT CIRCUIT CURRENT RATINGS

A. Unless otherwise noted, all HVAC equipment shall include a nameplate that identifies the short circuit current rating (SCCR). Unless otherwise noted the SCCR rating for all HVAC equipment shall be a minimum of 65 KA.

1.10. PACKAGED EQUIPMENT BACNET CARDS

A. For all packaged units, furnish and install Bacnet cards for interface to the automatic temperature control system. Map over all Bacnet points and alarms and show on ATC system graphics. All alarms must be identified on ATC graphic.

PART 2. PRODUCTS

2.1. AUTOMATIC GLYCOL MAKEUP SYSTEM

A. Furnish an automatic glycol feeder to provide consistent operating pressure in the closed loop system by feeding a controlled percentage of glycol solution. Glycol shall be made-up automatically from a pre-mixed solution tank. A low level switch shall prevent pump operation when solution level is too low.

B. The glycol feeder package to consist of a prewired control unit in a NEMA 1 steel enclosure and a pre-piped flow assembly including a pressure switch, pressure relief valve, 50 gallon polyethylene tank, low level switch, positive displacement pump, and pressure gauges.   Automatic glycol feed system shall be Pulsafeeder Model GF-1, or approved equal.

C. Glycol solution tank shall be 50 gallons polyethylene tank with steel supports for mounting the transfer pump below the tank. Provide hinged polyethylene cover, pump suction connection, and drain valve.

D. Positive displacement flooded suction pump rated at capacity as scheduled on the contract drawings.

E. Provide PVC piping from the tank to the pump with PVC ball valve and steel strainer. Include at discharge a check valve, ball type shutoff valve and pressure relief valve piped back to the solution tank.

F. Provide a dolly suitable for transporting 55 gallon drums to the charging station. Dollies shall be suitable for storing a drum in the horizontal position so that the solution may be drained into a transfer pail. Include spring loaded draw valve.

G. Provide 5 gallon plastic pail.

H. Provide low level switch and dry contacts for monitoring on the ATC system.

2.2. INDUSTRIAL INHIBITED PROPYLENE GLYCOL

A. Provide a 25 percent by volume (as installed) industrial grade inhibited propylene glycol heat transfer fluid as manufactured by the Dow Chemical Company (Dowfrost HD), Houghton, Interstate Chemical (Intercool P-300) Glycochill Plus or approved equal. The 25 percent solution shall provide freeze protection to 12 degrees F and burst protection to –20 degrees F. The propylene glycol solution as supplied by the manufacturer shall contain corrosion inhibitors specially formulated for cool storage services to keep internal surfaces free from corrosion and fouling and shall include buffers, reserve alkalinity agents, antifoaming additives, and a fluorescent dye to aid in leak detection. The solution shall be easily re-inhibited using specially formulated inhibitor readily available from the field manufacturer. The manufacturer shall provide free propylene glycol yearly solution laboratory analysis. The analysis shall accurately report propylene glycol concentration, freeze point temperature, inhibitor level, alkalinity, particulate and recommended additions of glycol, inhibitor and buffers to ensure twenty-year minimum life. The fluid shall pass the ASTM D-1384 test with less than 0.5 mils penetration per year.

B. Automotive antifreeze or any solutions containing silicates shall not be acceptable.

C. Propylene glycol shall be supplied preduilted with deionized water and installed in the specified piping systems.

D. Provide a Misco Products calibrated hand held refractor meter.

E. Provide one spare 55 gallon drum of glycol.

F. Contractor shall chemically clean and flush the completed propylene glycol system. As a minimum, system shall be cleaned with a 1 percent to 2 percent solution of trisodium phosphate in water. Provide temporary bypasses at the ice storage modules for the initial pressure testing, cleaning and flushing operations. This prevents the transfer of contaminants to the clean tubing in the modules. The system shall be thoroughly flushed using clean water and circulated for a minimum of 72 hours at which time water samples shall be taken by the contractor who shall certify that the system is free of particulate, mil scale, weld scale, solder flux, rust, metal filings, oil, grease, chlorides, sulphates, silicates and other foreign matter that could degrade the propylene glycol. After the system is charged with the approved heat transfer fluid, air shall be eliminated from the system, and the heat transfer fluid shall be circulated for 72 hours through all components. The contractor shall test and adjust the concentration to achieve 25 percent by volume propylene glycol.

G. Entire system shall conform to EPRI Standard propylene glycol systems 15751.

H. Flushing period (72 hours) shall be closely monitored to prevent excess heat build-up due to pump heat.

2.3. DENATURED ETHYL ALCOHOL (ENVIRONOL)

A. General

1. The geothermal heat transfer fluid shall be based on a renewable denatured ethyl alcohol (grain) approved and listed for use as a heat transfer/antifreeze with the United States Bureau for Alcohol, Tobacco and Firearms with the following qualities. The heat transfer fluid shall be Environal, Exoendosol, GeoSafe by Houghton Chemical Corporation, Geochill Plus by Greenway Products, or approved equal.

B. Appearance

1. The fluid shall have a pine aroma and be light blue in color

C. Performance

1. The performance shall be as follows:

a. Viscosity shall be no more than 5.00 centipoise at 30 degrees F with blend for 15 degrees F freeze protection.
b. Specific heat shall be 1.05 at 70 degrees F with blend for 20 F degrees freeze protection.
c. Specific Gravity shall be 0.982 at 50 degrees F with blend for 20 degrees F freeze protection.
d. Pressure drop and Reynold's Number for a 3 gpm flow in ¾" IPS SDR11PE pipe of a 30 degrees F mixture for a 15 degrees F freeze protection blend shall be no more than 2.83 Ft of hd per 100 ft of pipe and no less than Re-2028 (Reynolds number)
e. Freeze Protection: 25% by volume to provide 15 degrees Fahrenheit freeze protection.

D. Application

1. The fluid shall mix easily and readily with water and shall not damage or corrode common tools.

E. Corrosion

1. The fluid shall be compatible with iron, copper, red and yellow brass, polyethylene, PVC, viton, buna "N", neoprene and nylon, and shall contain an oxygen scavenger blend to reduce any corrosion capability.

F. Health

1. The fluid shall have an NFPA rating of 0 (least risk).

G. Furnish antifreeze pre-mixed with deionized water and install in the geothermal system.

2.4. GLYCOL FEEDER PRESSURE TANK

A. Provide and install glycol feeder pressure tanks of size, capacity and as indicated on contract drawings. Glycol feeder pressure tanks shall be Therm-X-TROL as manufactured by AMTROL Inc., Flexcon, Wessels, Taco or approved equal. Mount tank as detailed on the drawings.

B. Glycol feeder pressure tanks shall be specifically designed for use in glycol systems. Tanks shall be pre-charged to require pressure at the factory. The maximum working pressure shall be 150 psig. The maximum operating temperature shall be 200 degrees F. Expansion tanks shall contain removable FDA approved butyl bladder.

C. Before installation, Contractor shall adjust the tank air pre-charge pressures to equal glycol feed pump pressure.

D. The tank must be constructed in accordance with Section VIII of the A.S.M.E. boiler and pressure vessel code and stamped 150 psig working pressure.

E. Accessories: Pressure gauge and air charging fitting, tank drain, pre-charge as indicated on contract drawings and factory installed clip angles.

2.5. DUCTLESS SPLIT SYSTEM HEAT PUMP (INVERTER TYPE) (WALL MOUNTED)

A. The heat pump air conditioning system shall be a Mitsubishi Electric Series split type Sanyo, LG, Daikin, Samsung, or approved equal. The system to consist of a slim silhouette, compact wall mounted packaged evaporator section with matching Slim Line air cooled outdoor unit. The units shall be listed by Electrical Testing Laboratories (ETL) and bear the ETL label. All wiring to be in accordance with the National Electrical Code (N.E.C.). The units shall be rated in accordance with ARI Standard 240 and bear the ARI label. A full charge of R-32 or R-454B refrigerant for 50 feet of refrigerant tubing shall be provided in the condensing unit. A holding charge shall be provided in the evaporator. System SEER shall meet or exceed 1992 Federal Standards.

B. The units shall have a manufacturer's warranty for a period of one (1) year from date of installation. The compressor shall have a warranty of six (6) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of Mitsubishi Electronics America, Inc. This warranty does not include labor. Manufacturer shall have ten years experience in the U.S. market.

C. Capacity shall be as scheduled on the contract drawings.

D. The indoor unit shall be completely factory assembled and wired. The casing shall have a white finish. The evaporator fan shall be a high performance, forward curve line flow fan direct driven by a single motor. The fan shall be statically and dynamically balanced and run on permanently lubricated bearings. A manually adjustable change vane shall be provided. The vane shall have the ability to direct the air from horizontal to vertical. An adjustable guide vane shall be provided to manually change the air direction from lift to right. The evaporator coil shall be of nonferrous construction with smooth plate fins bonded to copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phoscopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan with drain shall be provided under the coil. Split system heat pump manufacturer shall furnish condensate lift pumps for field installation within the indoor unit. Condensate pumps shall be complete with float switch sensor, alarm, reed switch, relay, contact, adapters, and detection block etc., for a completely operational system. Contractor shall mount, pipe, and wire condensate pump per split system heat pump manufacturer's recommendations. Condensate pump shall be model EE as manufactured by Sauermann or approved equal. The units' electrical power requirements shall be as scheduled on the contract drawings.

E. The outdoor unit shall be completely factory assembled, piped, and wired. The casing shall be fabricated of galvanized steel, bonderized and finished with baked enamel. The unit shall be furnished with a direct drive, propeller type fan arranged for horizontal discharge. The motor shall have inherent protection, be of the permanently lubricated type and resiliently mounted for quiet operation. The fan shall be provided with a raised guard to prevent contact with moving parts. The variable speed compressor shall be of the high performance rotary type with accumulator and internal thermal overloads. The variable speed compressor shall be mounted so as to avoid the transmission of vibration. The refrigeration system shall have the capability to operate with a maximum height difference of 25 feet and overall refrigerant tubing length of 49 feet between indoor and outdoor sections without the need for line size changes, traps, or additional oil. Refrigerant flow from the condenser to be controlled by means of a capillary tube. The condenser coil shall be of nonferrous construction with smooth plate fins bonded to copper tubing. The coil shall be protected with an integral metal guard. The unit shall be controlled by the microprocessor located in the matching indoor unit. The unit electrical power requirements shall be as scheduled on the contract drawings. The outdoor heat pump unit shall be placed on vibration isolators and mounted on rooftop equipment rail or concrete pad as indicated. Inverter type compressor shall allow defrost without the need for auxiliary electric heat.

F. The control system shall consist of two (2) microprocessor section. One microprocessor section shall be factory wired and located within the indoor unit. It shall have the capability of sensing indoor coil temperature; receive and process commands from the hardwired remote controller; control the booster heater; and control the outdoor unit. The microprocessor within the wall mounted remote monitor and hardwired remote controller shall display set point; provide two (2) manually selected modes of cooling, normal and economy operation at 2 degrees above set point; provide manual heating selection; with set back operation of 4 degrees above set point for cooling and 4 degrees below set point for heating; and manual or automatic fan speed control. Automatic fan speed control shall be based upon the temperature difference between set point and room temperature maintaining lowest speed possible. The heating system shall be controlled so that only warm air is discharged whenever the indoor fan operates above the very low (VLO) speed. Heating shall be switched back to the heat pump only when the difference drops back to less than 3.6 degrees. The control voltage between the indoor unit and the outdoor unit shall be 12 volts D.C. The hardwired remote controller shall be wireless, using infrared line of sight for system control and shall include automatic ON/OFF timer; liquid crystal display; "I FEEL" control mode which adjusts temperature by tapping the button that describes the present condition "Too Cool", "Too Warm", or "OK". The optimum temperature set this way is memorized for immediate recall whenever the system is used again. The system shall be capable of automatic restart when power is restored after power interruption.

G. High condensate water safety shutdown: Each indoor unit’s detection unit shall be interlocked to alarm and stop the outdoor unit if a high condensate water level is sensed.

2.6. ELECTRIC RADIANT HEATERS

A. Electric Radiant Ceiling Panel

1. General: Provide electric radiant ceiling panels as indicated on the drawings. The electric ceiling heating panel shall be AZTEC, as manufactured by Berko, a Division of Marley Electric Heating, CP series as manufactured by Qmark or as approved equal. The construction and design shall permit it to be: recessed ceiling-mounted with the use of Recessed Mounting Kit, fit into standard or custom designed modules of a T-bar suspended ceiling, surface-mounted with the use of a Surface Mounting Kit, or exposed with the use of a surface mounting kit and duct strap attached to roof structure. In finished spaces with hard ceilings, install units recessed. Panels shall be UL listed. Panels shall include the custom features listed below.
2. Heating Assembly: The heating assembly shall be UL and CSA approved and shall consist of powdered graphite encapsulated in a plastic laminate with heavy duty copper buss bars running the entire length, backed by 1-inch, 1-pound density high temperature fiberglass insulation to insulate against heat loss to the ceiling and separated from the inside of the panel by a dielectric insulation to assure uniform heat transfer throughout the entire radiating surface of the heater.
3. Thermal Cutout: A thermal cutout shall be built into all high density panels to automatically shut off the heater in the event of overheating and reactivate the heater when temperatures return to normal.
4. Wiring: For connection to the main power supply, the heater shall be completely prewired, with the lead wires housed in a 40-inch length of flexible metal conduit and connector for J-Box mounting. Appropriate diagrams shall appear on the back of the panel. Provide modular connectors, pre-wired system for unit mounted end to end. Coordinate with Division 26.
5. Panel Assembly: The metal heating panel, containing the completely prewired heating assembly, shall be of 22 gauge formed galvanized steel front and 24 gauge formed galvanized steel back. Sides are overlapping front and back panels riveted together.
6. Finish: The front of the heating panel shall be multi-faceted cystalline type surface finished with high temperature silicone paint.
7. Controls: All radiant heaters shall be thermostatically controlled. When more than one radiant heater is shown in a space, provide the minimum number of thermostats required to control the total quantity of heating panels in the space. Thermostats, control transformers and associated controls shall be provided by the Manufacturer. Coordinate requirements with Division 26 and ATC

Subcontractor.

8. Features: Radiant heating panels shall be provided with the following features:

    a. Painted frame to match heater.
    b. Factory silicone scaled for shower rooms.
    c. Seal tight flexible conduit and connectors for shower rooms.

9. Thermostats shall be Q-Mark Model WRIE 30S Mercury Bulb, single pole single throw, 24 volt with 40 degrees F and 80 degrees F range. Provide and install stainless steel thermostat guards over all thermostats. Provide and install Q-Mark Model LTR2-277 dual level temp relays. Relays shall be enclosure mounted. Provide and install low voltage transformers as required.

2.7. HORIZONTAL ELECTRIC UNIT HEATERS

A. General: Provide horizontal electric unit heaters as indicated, of type and minimum capacity as scheduled, and as specified herein.

B. Furnish and install Emerson-Chromalox type MUH, Trane, Qmark, Markel, Marcor, Indeeco, or approved equal horizontal unit heaters with heating and air delivery capacities as shown on the heating schedule. The cabinet shall be made of 18 gauge die formed, furniture grade steel. Individual adjustable louvers with 30 degree downward stops shall be furnished to provide desire control of discharge air. All metal surfaces of the casing shall be phosphate coated to resist corrosion and finished in a decorative two toned neutral grey-bronze brown baked enamel. Mounting brackets designed for either ceiling or wall swivel mounting shall be furnished. Heater to be of the draw-through air flow design to eliminate element hot spots and extend design life.

C. For safety, the electric heating bank shall consist of Chromalox or equal metal sheath heating elements. The elements shall have a copper clad steel sheath for strength and corrosion resistance and aluminum fins for faster heat transfer. Automatic reset thermal over-heat protection, shall be of the linear capillary type wired for instantaneous de-energizing in case of thermal overload. Heating bank to have protective air inlet louvers.

D. All heaters drawing in excess of 48 amperes shall be provided with factory installed subdivided circuits of 48 amps or less.

E. Motors shall be of the totally enclosed continuous heavy-duty all-angle operation equipped with built-in thermal overload protection.

F. Fans shall be aluminum, directly connected to fan motor, designed specifically for unit heater application.

G. Low voltage control transformers shall be provided allowing safer more precise temperature control. Thermostat to be provided by mechanical contractor including relays, as necessary to accomplish specified sequence. Provide Chromalox Model UR-1E30 single stage, low voltage; 24 volt mercury switch thermostats with each unit heater.

H. Individual optional field installable control kits shall be provided with all models. All controls shall have pig tails and spade terminals for ease of wiring to centrally located terminal board. All heaters of 63 amperes or less shall be provided with power disconnect switches.

I. Furnish and install the following accessories for operation:

1. Wall/ceiling mounting bracket.
2. Low voltage thermostats with stainless steel wire guard.

J. All heaters shall be U.L. listed and meet the requirement of the National Electrical Code.

K. All units shall have built-in contactors and control circuit transformers to provide single source power connection. Built-in fuse blocks and factory supplied fuses shall be installed on all models. A wiring diagram and grounding LUG shall be included in each control compartment.

2.8. RECESSED ELECTRIC CABINET UNIT HEATER

A. Unit heaters shall be blow-through design with motor and fans in the air stream below electric heating bank. Fan discharge shall be baffled to insure even air flow through entire area of heating bank for even outlet temperatures. All models shall be floor or ceiling mounted as scheduled. Leveling bolts and bottom inlets shall be provided. Units shall be Type CU as manufactured by Chromalox, Marcor, Emerson, Trane, Markel, Qmark, Indeeco, or approved equal.

B. All solid panels of the front, top, and bottom panels shall be internally insulated to provide quiet operation and low surface temperatures. Complete unit assembly shall be listed and approved by Underwriter's Laboratory, Inc.

C. Base color shall be selected by the Architect. Casing shall be given a 5- stage phosphatizing treatment prior to application of high gloss baked enamel finish. Casing top and front shall be 16 gauge with 18 gauge front accent panel. Discharge grille shall be a continuous stamped louver. Front access panel fasteners shall be Phillips head.

D. For safety, the electric heating bank shall consist of metal sheath heating elements. The elements shall have a copper clad steel sheath for strength and corrosion resistance, and aluminum fins for faster heat transfer.

E. Fin tubes shall be installed or removed individually, and shall be center anchored to insure noiseless expansion and contraction.

F. Automatic reset snap-action type thermal protection shall be furnished through holding coil circuit of the control system relay(s) for protection in the event of overheating due to air blockage from any cause. Thermal protector shall be linear type to sense temperatures the entire length of heating elements, to detect localized overheating from partial air blockages.

G. Motor and fan assembly shall be direct drive on all unit sizes, using extended motor shaft on one fan unit, double extended motor shafts on two fan unit and coupling with hollow steel shafts and end bearing on three, four and five fan units. Two-speed permanent split capacitor type motors with built-in automatic reset motor overload protection shall be standard.

H. Fan shall be forwardly curved double inlet centrifugal type, aluminum construction - and shall be modular in design.

I. Motor and fans shall be mounted on an extra heavy 14 gauge galvanized mounting plate, forming an easily removable assembly. Motor leads shall be plug-in type for easy removal of the motor and fan assembly. Combination two-step, two-heat tamperproof switch shall be located with access through discharge air grille, using Allen key for adjustment.

J. A permanent reusable polyurethane type filter shall be provided. All models shall have filter access through removable front access panel.

K. All recessed units shall have wall-guard or ceiling type recess flanges which protect the wall/ceiling from direct contact and damage when access panels are removed or replaced for normal maintenance. Units are to be fully recessed.

L. Furnish and install a Chromalox model MHT-4051E-1007 thermostat with temperature adjustment range between 50 degrees F and 80 degrees F. Furnish control transformer wiring, thermostat stainless steel wire guard and all other control components as required.

M. An integral fan delay switch shall be standard, to prevent discharge of cold air, by delaying start-up of the fan motor until heating elements have warmed up. This same fan delay switch shall maintain motor operation after heating elements have been de-energized to dissipate any residual heat.

N. Units shall be equipped as standard with a two speed/two heat selector switch which permits simultaneous tamper-resistant "high-low" adjustment of fan speed and heat output by means of an Allen key though discharge grille.

O. A summer fan switch shall be provided to energize fans only for summertime operation.

P. Units shall have a built-in circuit breaker as a positive disconnecting means per the National Electrical Code.

2.9. FANS

A. General

1. Provide fans as indicated on the drawings. All fans shall have been tested and their performance rated in accordance with Air Movement and Control Association, Inc., Bulletin 210-85 Test Code and shall be licensed to bear the AMCA Seal. All fans shall carry the AMCA Certified Rating Seal for air and sound. Sound power levels shall be submitted for approval. Fan curves shall be submitted with all fan shop drawings.
2. Fan manufacturer shall submit under what duct configuration (unducted, partially ducted, or ducted) the manufacturer certified the performance of a particular fan or group of fans.
3. When indicated on Contract Drawings provide inverter duty rated motors for all variable speed fans.

B. In-Line Centrifugal Fans

1. Belt Drive

   a. Furnish and install in-line centrifugal belt drive fans of the size, capacity and electrical characteristics as shown on contract drawings.
   b. Duct mounted fans shall be of the centrifugal belt driven in-line type. The fan housing shall be of the square design constructed of heavy gauge galvanized steel and shall include square duct mounting collars.
   c. Fan construction shall include two removable access panels located perpendicular to the motor mounting panel. The access panels must be of sufficient size to permit easy access to all interior components. All in-line fans shall be factory insulated. The housing interior shall be insulated with 1-inch acoustical insulation.
   d. The fan wheel shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced.
   e. Motors shall be heavy duty ball bearing type, carefully matched to the fan load and furnished at the specified voltage, phase and enclosure. Motors and drives shall be mounted out of the airstream. Motors shall be readily accessible for maintenance. Motors shall be high efficiency type.
   f. Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed.
   g. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.
   h. Motor pulleys shall be adjustable for final system balancing.
   i. All fans shall bear the AMCA Certified Ratings Seal for both sound and air performance.
   j. Each fan shall bear a permanently affixed manufacturer's nameplate containing the model number and individual serial number for future identification.
   k. Explosion proof fans shall be provided with explosion proof motor and non-sparking explosion proof wheel construction.
   l. Fans shall be Model BSQ as manufactured by Greenheck Fan Corporation, ACME Engineering, Penn Ventilator, Cook, Twin City Fan and Blower or approved equal.

C. Sidewall Propeller Fans

1. Belt drive

   a. Furnish and install belt driven propeller fans of size, capacity and electrical characteristics as shown on contract drawings.
   b. All sidewall fans shall be belt driven axial type.
   c. Propellers shall be constructed with die formed galvanized steel blades riveted to a steel hub. Propellers shall be statically and dynamically balanced.
   d. Motors shall be of heavy duty ball bearing type, carefully matched to the fan load, and furnished at the specified voltage, phase and enclosure.

Two speed motors shall be furnished where indicated.

e. Ground and polished steel fan shafts shall be mounted in permanently lubricated, sealed ball bearing pillow blocks. Propellers shall be attached to fan shafts with a standard square key and set screws or tapered bushings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speeds. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. Motor sheaves shall be adjustable for final system balancing.

f. Drive frame assemblies shall be formed galvanized steel construction. Fan panels shall have prepunched mounting holes, formed flanges with welded corners and a deep formed inlet venturi.

g. The axial exhaust or supply fans shall bear the AMCA Certified Ratings Seals for both air and sound performance.

h. All steel parts shall be protected with thermally fused polyester urethane. Fan shafts shall be coated with a zinc phosphate corrosion resistant coating.

i. Fans shall be provided with OSHA Safety Guard. Supply fans shall be of the reverse flow configuration. Provide wall mount collars, and 2-inch aluminum birdscreen with each fan as indicated on contract drawings. Motor operated dampers shall be provided by ATC subcontractor and installed by mechanical contractor.

j. Fans shall be Model SBE for exhaust and SBS for supply as manufactured by Greenheck, ACME Engineering, Penn Ventilator, Cook, Twin City Fan and Blower or approved equal.

D. Kitchen Grease Hood Exhaust Fans (Belt Drive) (Upblast)

1. Provide and install belt drive upblast centrifugal roof exhauster of the size, performance, and electrical characteristics as indicated on contract drawings. The upblast exhaust fan shall be installed on a ventilated roofcurb.

2. Roof exhaust fans shall be upblast centrifugal belt driven type. The fan wheel shall be centrifugal backward inclined, Teflon coated constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced. The fan housing shall be constructed of heavy gauge aluminum with a rigid internal support structure. Windbands shall have a rolled bead for added strength and shall be joined to curbcaps with a welded seam.

3. Motors shall be heavy duty ball bearing type, carefully matched to the fan load, and furnished at the specified voltage, phase and enclosure. Motors and drives shall be mounted on vibration isolators, out of the airstream. Fresh air for motor cooling shall be drawn into the motor compartment from an area free of discharge contaminants. Motors shall be readily accessible for maintenance. Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators. Where scheduled to be variable speed provide inverter rated motors. Coordinate required VFD size provided in Division 23 Section “Packaged Kitchen Hood Ventilation Control System”.

4. Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed.

Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.

5. Motor pulleys shall be adjustable for final system balancing. A disconnect switch shall be factory installed and wired from the fan motor to a junction box installed within the motor compartment. A conduit chase shall be provided through the curb cap to the motor compartment for ease of electrical wiring. All fans shall bear the AMCA Certified Ratings Seal for sound and air performance.
6. The upblast exhaust fans shall be provided with baffled grease container, and shall be listed per U.L. 762. Fan discharge shall terminate a minimum of 40-inch above roof. Fan and installation shall comply with N.F.P.A.-96.
7. Provide fan with a minimum 36 inch wind band to elevate exhaust discharge.
8. Kitchen hood exhaust fans shall be Model CUBE as manufactured by Greenheck, Acme Engineering, Penn Ventilator, Cook, Twin City Fan and Blower or approved equal.

E. Upblast Centrifugal Roof Exhauster (Belt Drive, Non Grease, Dishwasher Hood Applications)

1. Provide and install belt drive upblast centrifugal roof exhauster of the size, performance, and electrical characteristics as indicated on contract drawings. The upblast exhaust fan shall be installed on a insulated roofcurb.
2. Roof exhaust fans shall be upblast centrifugal belt driven type. The fan wheel shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced. The fan housing shall be constructed of heavy gauge aluminum with a rigid internal support structure. Windbands shall have a rolled bead for added strength and shall be joined to curbcaps with a welded seam.
3. Motors shall be heavy duty ball bearing type, carefully matched to the fan load, and furnished at the specified voltage, phase and enclosure. Motors and drives shall be mounted on vibration isolators, out of the airstream. Fresh air for motor cooling shall be drawn into the motor compartment from an area free of discharge contaminants. Motors shall be readily accessible for maintenance. Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators. Motors shall be two (2) speed type or explosion proof where indicated on contract drawings.
4. Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.
5. Motor pulleys shall be adjustable for final system balancing. A disconnect switch shall be factory installed and wired from the fan motor to a junction box installed within the motor compartment. A conduit chase shall be provided through the curb cap to the motor compartment for ease of electrical wiring. All fans shall bear the AMCA Certified Ratings Seal for sound and air performance.
6. The upblast exhaust fans shall be provided with 2-inch aluminum birdscreen 12-inches high, fully insulated, aluminum roof curb. Fan and roof curb shall be provided by the same manufacturer.

7. Motor operated dampers shall be provided by ATC subcontractor and installed by mechanical contractor. Where indicated, provide tilting curb to allow damper access from roof.
8. Exhaust fans shall be Model CUBE as manufactured by Greenheck, Acme Engineering, Penn Ventilator, Cook, Twin City Fan and Blower or approved equal.

2.10. DRYER DUCT BOOSTER FAN (RESIDENTIAL TYPE DRYER)

A. Furnish and install in-line dryer duct booster fan of the size, capacity, and electrical characteristics as shown on the contract drawings. Dryer duct booster fan shall be Tjernlund or approved equal.

B. Duct mounted dryer duct booster fans shall be the direct drive type. The fan housing shall be constructed of 22 gauge G90 galvanized steel. The access for wiring shall be eternal. The unit shall be plug-in type. The motor shall be PSC, permanently lubricated ball bearing type and located outside the dryer exhaust air stream. The material handling impeller shall be reverse inclined, particulate handling impeller type, and be constructed of 18 gauge G90 galvanized steel.

C. Provide rubber isolated mounting bracket.

D. Dryer duct booster fan shall be Listed to ANSI/UL 507.

E. The dryer duct booster fan shall be controlled by an electronic Pressure Response Control (PRC). The control shall continuously monitor the pressure in the dryer duct. When the dryer is activated, dryer exhaust pressurizes the inside of the dryer duct, activating the dryer duct booster fan. When the dryer duct booster fan and dryer operating together, they establish a resulting pressure that is monitored by the PRC. When the dryer shuts off, this pressure decreases and the PRC shuts off the dryer duct booster fan.

F. Unit shall be hardwired and a disconnect installed to comply with NEC.

G. Unit shall be provided with a 5-year warranty.

2.11. PACKAGED KILN VENTILATION SYSTEMS

A. Furnish and install a complete positive pressure, kiln ventilation system of the size, capacity, and electrical characteristics as scheduled. System shall be as manufactured by Vent-A-Kiln Corporation or approved equal.

B. System shall include aluminum hood, fan/motor with "low/high/off" switch, 6-foot cord with plug, overhead counter weight pulley system, 10' flexible hose, clamps, and external mounting plate for sidewall discharge.

C. Furnish each system with an electronic programmable mini-time controller. Timer shall contain a LCD display and be fully programmable to schedule on/off time of hood system. Timer shall be designed to plug into a standard 115 volt receptacle.

D. Furnish each system with free standing, portable kiln safety screens. Screens shall be constructed of ½ -inch tubular steel frames with fire resistant canvas. Furnish standard unit with three hinged 2' x 3' panels. Each panel shall be imprinted in bright safety yellow paint with "caution - kiln in operation" sign.

2.12. BASE MOUNTED PUMPS - END SUCTION

A. Furnish and install base mounted centrifugal end suction pumps to circulate hydronic water to the various items of equipment throughout the building, associated with the HVAC system. Pumps shall have sizes and capacities as indicated on the drawings.

B. All pumps shall be suitable for the service and temperatures designated and shall conform to the following requirements. Each pump shall have a factory installed seal flushing line running from the seal area to the pump suction to insure removal of trapped air from the seal area, removal of sediment, and cooling of the seal to extend seal life. Provide and install Cuno five (5) micron filters in seal flushing lines. Provide two (2) sets of cartridges for each side - stream filter.

C. Pumps shall be cast iron bronze fitted and shall be suitable for up to 175 psi working pressure and up to 250 degrees F water temperature. Pumps shall have center-line discharge for positive venting and flanged bodies. Pumps shall incorporate a grease lubrication system and be so designed that the bearing assembly can be removed in one piece. A water slinger shall be provided between the mechanical seal and bearing areas. Pump shafts shall be stainless steel with a cupro-nickel sleeve, and be coupled to the motor shaft by a noiseless, non-metallic coupler with guard. Impellers shall be one piece cast bronze, dynamically balanced. Motors shall be 1750 rpm. For variable speed pumps, motors shall be inverter duty rated.

D. Pumps shall be designed so that they shall not overload at low heads and shall not develop excessive pressure under throttled flow conditions or overload motor anywhere on the operating curve. Operating performance curves shall be submitted for approval. Provide gauge tappings on each pump flange. Furnish dust caps at all oil fill tubes. Pump motors shall be non-overloading throughout the range of the curves.

E. When pumps are operated in parallel, pumps must be selected so as not to “run-out” to the end of the pump curve. Submit pump curves for parallel pump operation and single pump operation.

F. Units shall be provided with motors of not less than the horsepower indicated, suitable for the service and available electrical characteristics. Units shall be controlled as hereinafter specified. After installation and prior to operation, each pump shall be aligned. Motors shall be as specified hereinbefore.

G. Casing: Cast iron, with suction and discharge gage ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.

H. Impeller: Bronze, fully enclosed, keyed to shaft.

I. Baseplate: Cast iron or fabricated steel with integral drain rim.

J. Pumps shall be primed and painted in baked enamel, rust resistant paint.

K. Electrical characteristics shall be as scheduled on the contract drawings. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA-70.

L. Pumps shall be FE series as manufactured by Taco, 2000 Series by Allis Chalmers, Aurora, Bell & Gossett, PACO, Armstrong, Patterson, or as approved equal.

2.13. IN-LINE CLOSE COUPLED CIRCULATING PUMP

A. Furnish and install in-line closed coupled circulating pumps as shown on the contract drawings. Pump and motor shall be equipped with permanently lubricated bearings for quiet operation. Pumps shall be suitable for up to 150 psi working pressure and up to 225 degrees F water temperature as per ASA B16.1. Pump rating curves shall be the result of testing and rating in accordance with the procedures of the Hydraulic Institute.

B. The pumps shall be of the horizontal, permanently lubricated type, specifically designed and guaranteed for quiet operation.

C. Provide gauge tappings on each pump flange.

D. The pumps shall have a steel shaft supported by permanently lubricated, sealed precision ball bearings. The pumps are to be equipped with a water-tight seal to prevent leakage. Mechanical seal faces to be carbon on silicon carbide. The motor shall be non-overloading at any point on the pump performance curve.

E. The motor shall be of the drip-proof, sealed precision ball-bearing, quiet-operating construction. The permanent split-capacitor motor shall be equipped with thermal overload protection.

F. Pumps to be suitable for 0 degrees to 225 degrees F (107 degrees C) operating temperature at 150 psig (10 bar) working pressure.

G. Pumps shall be provided with all bronze construction when used in open systems and shall be bronze fitted for closed systems.

H. Electrical characteristics shall be as scheduled on the contract drawings. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA-70.

I. In line pumps shall be close coupled in-line circulators Model PL as manufactured by Bell & Gossett, Thrush, Armstrong, Taco, Patterson, or as approved equal.

2.14. VARIABLE SPEED DRIVES

A. Provide variable speed drive controllers for Pumps as indicated on contract drawings. Drive shall be subject to the requirements of this section.

B. ERV variable speed drives shall be factory furnished by ERV unit manufacturer.

C. Kitchen make-up air unit and kitchen exhaust fan variable speed drives shall be factory furnished with the packaged kitchen hood ventilation control system. Under this Division install VFDs where indicated on the Contract Drawings.

D. The adjustable frequency controller (AFC) shall convert three phase 60 Hertz utility power to adjustable voltage and frequency, three phase, AC power for stepless motor control from 5 percent to 110 percent of base speed.

E. The AFC shall be a voltage source type with a PWM output utilizing power transistor semi-conductors.

F. The AFC together with all options and modifications shall mount within a standard NEMA 1 enclosure or NEMA-4X for exterior installation suitable for continuous operation at ambient temperature of 0 to 40 degrees C. with relative humidity to 95 percent non-condensing. All high voltage components within enclosure shall be isolated with steel covers. The complete unit shall be UL approved and UL labeled.

G. Circuits shall provide DV/DT and DI/DT protection for semi-conductors. AFC shall be capable of starting into a rotating load without delay. Protective circuits shall cause instantaneous trip (IET) should any of the following faults occur:

1. Motor overload.
2. Shortcircuit.
3. Motor overtemperature fault.
4. Reverse phase.
5. 110 percent of controller maximum sine wave current rating is exceeded.
6. Output phase to phase and phase to ground short circuit condition.
7. High input line voltage.
8. Low input line voltage.
9. Loss of input phase.
10. External fault. This protective circuit shall permit, by means of the terminal strip, wiring of remote NC safety contacts such as high static, firestat, etc., to shut down the drive.

H. The following adjustments shall be available in the controller and retained in non-volatile memory:

1. Maximum frequency (15 to 400 Hz) factory set at 60 Hz.
2. Minimum frequency (3 to 60 Hz) factory set at 6 Hz.
3. Acceleration (.1 to 360 seconds) factory set at 20 seconds.
4. Deceleration (.1 to 360 seconds) factory set at 20 seconds.
5. Volts/Hertz ratio factory set for 460V at 60 Hz.
6. Voltage offset or boost factory set at 100 percent torque.
7. Current limit (50 percent to 110 percent sine wave current rating) factory set at 100 percent current.

I. The AFC shall have the following basic features:

1. Door-mounted operators controls consisting of a membrane command center which allows manual stop/start and speed control, local/remote indication and manual/or automatic speed control selection. In addition, the command center shall serve as a means to configure controller parameters such as min speed, max speed, acceleration and deceleration times, Volts/Hz ratio, torque boost etc. Potentiometers shall not be allowed for these settings.
2. Main input disconnect to provide a positive disconnect between the controller

and all phases of the incoming A-C line. This disconnect shall be mounted inside the controller enclosure and have through-the-door interlocking toggle with provisions for padlocking.

3. Electronic motor overload relay.
4. Automatic restart after power outage, drive fault or external fault, with drive in automatic mode. The circuit shall allow the user to select up to (10) restart attempts as well as the dwell time between attempts. The reset time between fault occurrences shall also be selectable. All settings shall be via the membrane command center.
5. Door-mounted LED display for digital indication of:

   a. Frequency output
   b. Voltage output
   c. Current output
   d. First fault indication
   e. Fan or Pump Speed (RPM)

6. Relay contacts for remote indication of drive fault and motor finning.
7. Three critical frequency avoidance bands, field programmable via the membrane command center. Each critical frequency avoidance band shall have a bandwidth adjustable via keypad entry of up to 10 Hz.
8. Three programmable preset speeds which shall force the AFC to a preset speed upon a user contract closure.
9. Isolated process follower to enable VFC to follow a 4-20 mA signal.
10. The AFC shall have the capability to ride through power dips up to 500 msec without a controller trip depending on load and operating condition.
11. Line reactor to minimize line surges, line notching, and voltage distortions. Line reactor shall be installed upstream of the drive.

J. Manual bypass-to-line with magnetic contactors to transfer motor from the variable frequency controller to full speed operation on utility supplied input power while the motor is at any speed. Two motor contactors, electrically interlocked shall be utilized, one contactor between the controller output and the motor and the other between the bypass power line and the motor, providing across-the-line starting.

K. Motor protection per National Electrical Code shall be provided in both the "controller" mode and the "bypass" mode by a motor overload relay. The 115 volt A-C relay control logic, allowing common start/stop commands in the "controller" mode and the "bypass" mode shall also be included within the enclosure.

L. The bypass shall include a door interlocked, main power input circuit breaker providing positive shutdown of all power to both the bypass circuitry and the VFC. The bypass circuit shall also include a second input disconnect to the VFC. This disconnect shall provide the ability to safely troubleshoot and test the controller, both energized and de-energized, while operating the bypass mode.

M. The VFC and all components shall be supplied within a single NEMA 1 enclosure, and shall be U.L. Listed as a single unit. Furnish all components necessary to provide a minimum lead length between motor and drive of 400 ft. The VFC shall not generate damaging transistor pulses greater than the limits set by NEMA MG-1 at 400 Ft lead length.

N. The VFC manufacturer shall maintain and staff nationwide service centers. These service engineers shall be employed by the manufacturer and provide start-up service including physical inspection of drive and connecting wiring and final adjustments to meet specified performance requirements.

O. The VFC shall carry a full parts and labor warranty for two years from date of substantial completion.

P. The variable speed drive shall be ABB, or approved equal of Accutrol, Cutler Hammer, Graham, York, Baldor, AC Tech, Trane, Emerson, Danfos, Yaskawa, Toshiba, or as approved equal.

Q. The variable speed drive manufacturer shall coordinate with the ATC contractor and provide all necessary devices whether optional or not to perform complete and automatic operation as described in the sequence of operation. All safeties, including freezestats, duct smoke detectors, and high static pressure sensors shall be enabled when variable speed drives are in manual or bypass.

R. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status and alarms. Allows VFC to be used with an external system within a multidrop LAN configuration; settings retained within VFC's nonvolatile memory.

1. Network Communications Ports: Ethernet and RS-422/485.
2. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet; protocols accessible via the communications ports.

S. Variable speed drives shall be carefully selected for the duty required. Variable speed drives shall be specifically designed for the specified equipment to be controlled. Pump drives shall be selected for pumps and fan drives shall be selected for fans.

2.15. COMBINATION COALESCING AIR AND DIRT SEPARATOR

A. Furnish and install as shown on the drawings a Spirotherm steel, Taco Series 4900, Caleffi , Armstrong, Wessels, or approved equal air elimination and dirt separator. All fittings shall be fabricated steel, rated for 150 psig design pressure and selected for less than 1 foot of water pressure drop and velocity not to exceed 4 feet per second through the unit at specified GPM. All units shall include an integral copper bundle of Spirotubes or approved equal, to act as the turbulence suppressive coalescing medium which must completely fill the fitting's internal area. Units are to remove free and entrained air during system start up and continue to eliminate dissolved air and dirt through continual circulation and the coalescing action of the Spirotubes. Each fitting is to have a separate air and venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral float actuated brass air vent. There shall be no restriction in the connection from the venting chamber to the vent. The fittings are to include a valve side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill. Units shall include a bottom connection for use as a blow down connection for periodic cleaning. Unit shall have the bottom of the vessel extended for dirt separation with the system connection nozzles equal distant from the top and bottom of the vessel. Air separator shall be primed and finished in rust resistant paint. Units shall be Spirovent dirt models of the size required to meet pressure drop and velocity criteria.

B. A blowdown connection and valve shall be provided to facilitate routine cleaning of the strainer and the separator. Unit shall include a removable lower head to facilitate removal of the tube assembly for cleaning.

C. A manufacturer's data report for pressure vessels, for U-1 as required by the provisions of ASME Boiler and Pressure Vessel code, shall be furnished for each air separator upon request. Manufacturer to furnish data sheet specifying air collection efficiency and pressure drop at rated flow.

D. Conventional tangential or centrifugal non-coalesing air separators shall not be acceptable.

E. Install shut-off valve between air separator and high capacity automatic air vent.

2.16. EXPANSION TANKS

A. Furnish and install as shown on the drawings, pre-pressurized captive air bladder type expansion tank pre-charged with air. Tank shall be suitable for a maximum working pressure of 125 psi and constructed and certified to ASME Section VII. It shall have a replaceable elastomeric bladder suitable for a maximum operating temperature of 240 degrees F (115 degrees C). Expansion tanks shall be primed and finished in rust resistant paint. It shall have an integral steel base ring for vertical mounting and saddle for horizontal mounting. Expansion tank shall be as manufactured by Taco, Bell & Gossett, Wessels, Amtrol, Armstrong or as approved equal.

2.17. HYDRAULIC SEPARATORS

A. Provide and install a dual temperature buffer tank / hydraulic separator for use with water to water heat pumps of the size, dimensions, and capacity as indicated on the contract drawings/schedules. Tank shall be as manufactured by Lochinvar (Model BVU), Cemline, SEB series, or approved equal.

B. The buffer tank / hydraulic separator shall be constructed in accordance with ASME Boiler and Pressure Vessel Code Section VIII Div. 1, Part U requirements, stamped and registered with the National Board of Boiler and Pressure Vessel Inspectors. The tank shall be furnished with flanged source system connections and flanged load connections for system supply and return. Tank size, piping tapping size and piping tapping quantity shall be as scheduled on contract drawings. Provide relief valve tapping, drain pipe tapping and temperature sensor tappings as scheduled on contract drawings. The tank shall be constructed with a built-in air separator with automatic air vent. Provide 12x16 manway for tank.

C. The buffer tank / hydraulic separator shall have a working pressure of 125 PSI (at 400 degrees Fahrenheit) and shall be channel iron skid mounted with lifting lugs. The buffer tank / hydraulic separator shall carry a five-year warranty against tank failure resulting from defects in materials or workmanship.

D. The buffer tank / hydraulic separator shall be constructed with a heavy gauge galvanized steel jacket assembly, primed and pre-painted on both sides with a minimum dry film thickness of 0.70 mills. The buffer tank / hydraulic separator shall be completely encased in a minimum of 2" thick, high density, HCFC free, polyurethane foam insulation to meet the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard.

E. Tank shall be factory furnished with all inlet, outlet, thermometer, relief-valve, temperature sensor and air vent tappings.

F. Provide factory furnished and installed A.S.M.E. pressure/ temperature relief valve. Pipe relief valve to nearest floor drain with union on discharge piping.

G. Mount tank on a 4-inch high housekeeping pad.

H. Provide factory furnished and installed A.S.M.E. pressure/ temperature relief

2.18. KITCHEN MAKE-UP AIR UNIT

A. Provide and install outdoor rooftop central station air handling units as shown and scheduled on the plans. The units shall be installed in a neat and workmanship like manner in strict accordance with the specifications. Rooftop air handling units shall be as manufactured by York, Trane, McQuay, Carrier, Mammoth, Aaon, Seasons 4, or approved equal.

B. General

1. Rooftop unit manufacturer's standard materials and components as indicated by published product information, designed and constructed as recommended by the manufacturer and as required for a complete air handling unit installation as specified herein. The air handling unit shall be specifically designed for curb mounting in an outdoor application. Weatherized indoor air handling units are not acceptable.
2. Rooftop unit shall meet or exceed the scheduled cooling and heating capacity, selected and rated in accordance with ARI 410. All necessary components for meeting scheduled performance shall be factory assembled per ARI 430 and shipped as one (1) piece where possible.
3. Rooftop units shall be provided with all necessary tags and decals to aid in the service and/or indicate caution areas. Electrical wiring diagrams shall be attached to the control panel access door. Lifting lugs will be supplied to facilitate rigging of the rooftop unit.
4. Manufacturers: The design shown on the drawing is based upon products of the manufacturer scheduled (York). Alternate equipment manufacturers will be acceptable if equipment meets the scheduled performance and complies with these specifications. If equipment manufactured by manufacturer other, than that scheduled is utilized, then the Mechanical Contractor shall be responsible for coordinating with all other Contractors and all affected Subcontractors to insure proper provisions for installation of the furnished unit. This coordination shall include, but not limited to, the following:

    a. Structural supports for units.
    b. Piping size and connection/header locations.
    c. Electrical power requirements and wire/conduit and over current protection sizes.

d. The Mechanical Contractor shall be responsible for all costs incurred by the other contractor, Subcontractors, and Consultants to modify the building provisions to accept the furnished units.

5. The units shall be furnished complete with double wall insulated casings, centrifugal fans, coils as scheduled, insulated drain plans, motor, drives, belt guards, filter boxes, outside air damper section, roof curbs, discharge plenums and accessories as required. Coils shall not exceed a face velocity of 525 feet per minute.
6. All units shall be horizontal draw through medium pressure units. Construct casing section located upstream of supply fan for operation at a minimum 4 inches w.g. negative static pressure and downstream section for operation at a minimum of 6 inches water gauge positive static pressure.
7. All units shall be factory primed and finished in colors as selected by Architect.
8. Fan discharge arrangements shall be coordinated with ductwork layout to minimize "system-effect" per AMCA Publication 201-90.
9. All glycol dual temperature coil capacities shall be based on scheduled percentage of propylene glycol.
10. Unit shall be factory wired as a single point connection. Each connection shall contain a disconnect in accordance with the National Electric Code.
11. Provide a GFCI receptacle with each unit. Receptacle shall be wired separate from unit wiring as indicted in Division 26.

C. Construction

1. Rooftop unit shall be supplied with a full length, continuous bass rail channel.

a. The base rail channel shall be formed of 12 gauge minimum galvanized steel.
b. The base rail channel shall support all major components.
c. The unit base shall be supplied with a recessed curb mounting location.

i. The recessed curb-mounting surface shall provide a continuous surface for field application of curb gasketing to create a weather-tight seal between the curb and unit.
ii. Units without a recessed mounting location for the roof curb shall not be acceptable.

2. Rooftop unit shall be supplied with a frame construction consisting of integral galvanized steel vertical and horizontal structural members.

a. The frame shall be constructed to permit complete removal of the wall and roof panels without affecting the structural integrity of the unit.

3. Rooftop unit shall be supplied with double walled panels for walls, roof, and floor constructed of G90 mill galvanized sheet steel.

a. All panels shall be formed and reinforced to provide a rigid assembly.
b. The exterior casing shall be constructed of 18 gauge minimum galvanized steel.

i. Exterior casing screws shall be zinc chromate coated.

c. The interior lining of the walls and roof panels shall be a solid lining of 20 gauge minimum galvanized steel.
d. The interior lining of the floor panels shall be a solid lining of 18 gauge minimum galvanized steel.
e. All walls, roof, and floor panels in the rooftop unit shall be supplied with 2-inches (two inches) of insulation.

i. Insulation shall be a full 2-inches (non-compressed) throughout the entire unit.
ii. Insulation shall be of 1.5 pound per cubic foot in density with a thermal conductivity R of 8.33 BTU/hr-Ft5 - degree F.
iii. Units with less than 2-inch of insulation in any part of the walls, floor, or roof shall not be acceptable.
iv. Insulation shall meet the flame and smoke generation requirements of NFPA 90A.

f. All wall and roof panels shall be completely removable for unit access and removal of components.

i. Panel removal shall not affect the structural unit frame.

g. All panels shall be completely gasketed with a copolymer rubber sealant ribbon.
h. All panel fasteners shall be secured through standing seams to prevent fastener penetrations that are exposed to the airstream.
i. Roof and sidewall seams shall be continuously caulked and covered with formed 20 gauge galvanized seam caps.

4. Rooftop unit shall be supplied with a sloped roof to promote drainage of precipitation and prevent standing water.

a. The roof shall have a minimum pitch of 3-inches per foot.
b. The roof shall overhang the side panels by a minimum of 2 inches to prevent precipitation drainage from streaming down the unit side panels. (Roof shall not overhang doors.)
c. Units supplied with flat roofs shall not be acceptable.

D. Fans

1. Units shall be provided with double width double inlet, centrifugal type wheels. Fans shall be standard or Class II (as required by total static pressure) forward curved wheels, air foil type, or backward inclined as scheduled. Every fan shall be rated in accordance with AMCA standards and the fan section shall be certified in accordance with ARI Standard 430. Fans shall be selected to operate well below the first critical speed and each shaft shall be factory coated after assembly with an anti-corrosion coating. After the pre-balanced fan is installed in the rooftop unit the entire fan section shall be run to assume smooth and trouble free operation.
2. Fan bearings shall be self-aligning, pillow block or flanged-type regreasable ball

bearings and shall be supplied for an average life (L50) or 200,000 hours. All bearings shall be factory-lubricated and equipped with standard hydraulic grease fitting and extended lube lines. Provide dust caps on all hydraulic grease fittings.

3. Mount fans on isolation bases. Internally mount motors on same isolation bases and internally isolate fans and motors with spring isolators. Install flexible canvas ducts between fan and casings to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A. The fan and fan motor shall be isolated on a full width isolator support channel using rubber in shear 2-inch springs.
4. Fan section shall have full height, double wall, hinge removable access doors for inspection and maintenance of internal components.
5. Weight fan and motor assembly at rooftop unit manufacturer's factory for isolator selection. Statically and dynamically balance fan section assemblies. Fan section isolators. Allow isolators to free float when performing fan balance. Measure vibration at each fan shaft bearing in horizontal, vertical and axial directions. Balance at design RPM's as schedule on drawings.
6. Fans with variable frequency drives shall be balanced for inverter duty operation. Refer to Schedule on Contract Drawings to determine what units are variable speed. Refer to Division 23 Section “Common Work Results for HVAC” for VFD motor bearing protective rings.

E. Motors and Drives

1. Fan motors shall be internally mounted. Rooftop units shall be provided with additional cooling capacity to compensate for motor heat added to airstream. Total cooling capacity, as schedule, shall be increased by 2500 btuh per motor horsepower for units with internally mounted motors.
2. Units shall be provided with the motor efficiencies as specified in Division 23 Section, Common Work Results for HVAC.
3. Motors shall be open NEMA Design B, rigid base, open drip proof, with Class B insulation. Where scheduled, variable speed units shall have inverter duty motors.
4. Fan drives shall be selected for a 1.5 service factor and anti-static belts shall be furnished. One additional set of belts shall be provided for each air handling unit and delivered to the Owner's representative at the completion of the project.
5. Fan sections shall be equipped with double width double inlet, centrifugal type wheels.
6. Drives shall be variable pitch and suitable for adjustment within plus or minus 15 percent of specified RPM but not to exceed the maximum RPM of the unit.
7. Motors shall be premium efficiency inverter duty type. Refer to Division 23 Section, “Common Work Results for HVAC”. Coordinate required VFD size provided in Division 23 Specification Section, Packaged Kitchen Hood Ventilation Control System.

F. Coils

1. Dual Temperature Water Coil: Dual temperature water coils shall be UL listed; factory tested and rated in accordance with ARI 410. Coils shall be copper with ½ -inch OD seamless tube, 0.022-inch tube thickness and 0.006-inch thick fins or 5/8-inch OD seamless tube, 0.020-inch tube thickness and 0.0075-inch thick fins. Coils shall be tested with 315 psig air pressure under water and maximum

working pressure of 250 psig and temperature of 300 degrees F. Fins shall be permanently expanded aluminum, with a maximum of 12 fins per inch. Coil face velocity shall not exceed 500 feet minute.

2. Coil casing shall be constructed of heavy gauge galvanized metal with aluminum die-formed corrugated fins and guide channels to create turbulent wiping behind the tubes. The fins shall have drawn collars, be belled and mechanically expanded to firmly bound the cooper tubes to the fins. All coils shall be installed on tracks for easy removal from the air handling unit.
3. Drainable water coils shall be designed to operate at 250 psig design working pressure and up to 300 degrees F and shall be tested with 325 psig compressed air under water. Circuiting shall provide free draining and venting when installed, counter flow of air and water with water velocities not to exceed seven feet per second and without exceeding the water pressure drops scheduled. All coils must have same end connections regardless of the number of rows deep. Clearly label supply and return headers on outside of units such that direction of coil water flow is counter to direction of unit airflow.
4. Construct coils of configuration plate fins and seamless tubes. Fins shall have collars drawn, belled and firmly bonded to tubes by means of mechanical expansion of tubes. Do not use soldering or tinning in bonding process.
5. Construction coil casings of Galvanized G90-U Steel with formed end supports and top and bottom channels. If two or more coils are stacked in unit, install intermediate drain channels between coils to drain condensate to main drain pans without flooding lower coils or passing condensate through airstream.
6. The make-up air unit shall be factory furnished with electric heating coil of size and electrical characteristics specified on the drawings. Electric heater shall meet all NEC and UL1096 requirements. All components shall be UL listed. Heater shall be wired with an airflow switch to prove air flow before energizing. Heater shall include a modulating SCR step controller, circuit fusing, high limit and a fused door interlocking disconnect switch.
7. Coil grommets shall be provided on all coils to completely seal the area between the coil connection and the unit casing.
8. Wrap Around Heat Pipe: De-humidifier heat pipe shall pre-cool the outdoor air and reheat the air leaving the cooling coil in a wrap around configuration. Both heat exchangers shall be inside and integral to the equipment cabinet. Tubes shall be ½ -inch OD seamless copper tube, 12 fins per inch and 0.006-inch thick fins. Fins shall be permanently expanded aluminum. Wrap around heat pipe shall be UL listed. Heat transfer fluid shall be classified as Safety Group A1 in BDR/ASHRAE Std. 15-1989R.

G. Filters

1. Rooftop unit shall be supplied with a filter segment as an integral part of the unit.
2. Filters shall be nominal 2-inch standard size filters; 45percent efficient pleated media type. Filters shall be Farr medium efficiency pleated, type with welded wire media support grid.
3. Provide one additional set of filter media for each rooftop unit to be delivered to the Owner's representative upon completion of the project.
4. Provide factory installed differential pressure gauge, two static pressure tips, vent valves, and red pointer flag, and air filter gauge accessory package to measure filter resistance. Accuracy shall be + - 2 percent of full scale - to 2.0 inch w.g. range. Gauges shall be 2003 magnahelic by Dwyer Instruments or approved

equal.

H. Access Sections and Access Doors

1. Fully insulated, access, sections shall be provided as indicated on the drawings. Sections provide a minimum of 18-inch space with fully-size access door. Access for inspection and cleaning of the unit drain pan, coils, fans sections, filter, wrap around heat pipes, and inlet sections shall be provided.
2. Access doors shall be provided in all sections as indicated on the drawings. Access doors shall be of double wall construction.
3. Panels shall be fully removable to allow for a proper way to thoroughly clean panels of microbial growth and to access internal parts.
4. Doors shall be of double wall construction with a solid liner.
5. Doors shall have a minimum thickness of 2-inches.
6. Doors shall be attached to the unit by a continuous, full length piano type stainless steel hinge. All doors and access sections shall be labeled and identified on the exterior of the unit.
7. Latches shall be positive action, creating an airtight seal between the door and the unit.
8. In lieu of the standard latch, doors for units larger than 6 feet shall be available with a single point, multi-latch system including handles on the interior and exterior of the door.

   a. Latch system shall include a 3 point deadbolt latch with flat rods and tapered take-up side bolts, stainless steel outside handle designed for 90 degrees rotation, and zinc plated inside handle.

9. Door panels shall be completely gasketed with a closed-cell neoprene gasket.
10. Provide access section down stream of dual temperature coil and upstream of heat pipe re-heat coil to allow installation of coil sensor and freezestats.

I. Rooftop unit shall be provided with internal or external pipe chase to enclose field piping and valves.

1. Pipe chase shall be 24 inches in depth.
2. Pipe chase shall be of double wall construction and include access doors.

J. Damper Section

1. Rooftop unit shall be supplied with a damper segment to provide a means of providing fresh air to the rooftop unit.

   a. The outside air segment shall consist of multi-leaf, parallel acting ultra low leak blades.
   b. The outside air dampers shall be sized for 100 percent of unit airflow.
   c. A weatherproof louver and bird screen assembly shall protect the outside air dampers from the elements.

      i. The outside air dampers shall be furnished with the rooftop units. Dampers in the damper segment shall be ultra low leakage dampers with a leakage rate not to exceed 3.0 CFM/Ft5 @ 1-

inch w.g. Dampers blades shall be airfoil type with extended vinyl edge seals and stainless steel jamb seamless. Dampers blades shall be parallel acting. Actuators shall be provided and installed by the ATC Contractor.

K. Rooftop units shall be supplied with a demount segment to allow for a unit split for shipping or installation purposes.

L. Rooftop unit shall be supplied, with the manufacturer's standard curb, shipped loose for field installation prior to unit placement

1. Roof curb shall be a prefabricated galvanized steel-mounting curb.
2. Roof curb shall be a perimeter type with a complete perimeter support of the air handling unit.
3. The curb shall be a minimum of 18 inches high.
4. Gasketing shall be provided for field mounting between the unit base and the roof curb.
5. The curb shall include a 2-inch x 4-inch wood nailer.
6. The roof curb shall be insulated with 2-inch thick 3 pcf insulation.
7. The roof curb shall be sloped to accommodate installation on a sloped surface where required.

M. Finishes

1. Rooftop unit shall be painted prior to shipment.

a. The exterior of the unit shall be completely cleaned prior to application of finished coats.
b. A prime coat of two component epoxy wash shall be applied to the unit.
c. A finish coat of machine acrylic polyurethane shall be applied to a minimum thickness of 2.5 mills. Color selection by Architect.
d. The finished unit shall exceed 500 hour salt spray solution (5 percent) without any sign of red rust when tested in accordance with ASTM B-117

N. Installation

1. Install rooftop units where shown, in accordance with equipment manufacturer's written instructions, and with recognized industry practices, to ensure that units comply with requirements and serve intended purposed.

2.19. EXTERIOR EQUIPMENT/DUCT SUPPORT

A. Exterior Equipment Supports shall be Pate Model ES suitable for roof construction. Equipment supports shall be constructed of 18 gauge galvanized steel, unitized construction with integral base plate, continuous welded corner seams, pressure treated wood nailer counterflasing and lag screws. Units shall be internally reinforced. Minimum height shall be 12-inches above the finished roof or as shown on the detail(s) on the drawing(s).

2.20. EXTERIOR ROOFTOP PIPING SUPPORT (NON-PENETRATING)

A. Exterior Piping Supports shall be non penetrating roof piping supports suitable for roof construction as manufactured by RTS – Rooftop Support Systems, Eberl Iron Works, Inc., Miro Industries. Pipe supports shall be constructed of 18 gauge stainless steel, unitized construction with integral base plate. Units shall be internally reinforced. Minimum height shall be 12-inches above the finished roof or as shown on the detail(s) on the drawing(s). Provide all stainless steel hardware. Duct support shall be "double support" type with adjustable height and width. Base shall be non-penetrating type, heavy duty rubber, manufactured from 100% recycled crumb rubber.

B. Pipe Supports: The pipe supports shall be elevated pipe roller supports. To allow for expansion and contraction the supports shall include pipe rollers, threaded rods, and supporting hardware. All supports shall be type 304 stainless steel with stainless steel hardware. Furnish with pipe straps to restrain pipes on the rollers.

2.21. STATIC PRESSURE GAUGES

A. Furnish and install where indicated, magnahelic static pressure gauges to measure the static pressure of dishwasher machine canopy hood, as specified or detailed.

B. Differential pressure gauges for measuring static pressure shall be the diaphragm, activated dial type 4-3/4-inch O.D., with white dial, black figures and graduations and pointer zero adjustment. Gauge shall be Dwyer Instruments, Inc. magnahelic with .5 inch water column range in .01 divisions.

C. Provide each unit with static pressure accessory package including aluminum surface mounting bracket with screws, ¼ -inch aluminum tubing, a single stainless steel static pressure tip and two molded plastic vent valves, integral compression fittings on both tips and valves.

D. Actual dial shall be remote located and sufficient ¼ -inch aluminum tubing shall be provided to install gauge on wall adjacent to hood or as indicated on contract drawings.

E. Provide air gauges with integral adjustable signal flag with external reset screw.

2.22. WATER TREATMENT SERVICES

A. Complete chemical water treatment service shall be provided by an organization regularly engaged in water treatment, ARC, Inc., RCCO Corp., Aquatel Ind., Inc., Mogul Corp., Oilin, Inc., HVAC Services, Inc., Feedwater Treatment Systems, Inc., Eco-Lab, Kurita, or approved equal. The service shall provide all equipment, chemicals and labor necessary to prevent corrosion, inhibit scale build-up and minimize organic growth for a period of two (2) years starting from building acceptance. Service visits for the purpose of adding chemicals to feeding equipment, regulating bleed-off, inspecting and adjusting water treatment equipment, and obtaining samples of laboratory analysis shall be performed at monthly intervals for closed systems and every two weeks for open systems during the entire guarantee period. Chemicals shall not be injurious to water side equipment and construction materials. Records of all injurious to water side equipment and construction materials. Records of all service visits, chemical additions, laboratory tests, etc., shall be maintained and shall be provided to owner after each visit during guarantee period. Instruct mechanical contractor in field on piping and wiring of chemical feeding equipment.

B. Systems to be protected shall include dual temperature and geothermal systems. Services shall include flushing and cleaning of piping systems specified under Division 23 Section, "HVAC Piping, Fittings, and Valves" section, furnishing and installing all chemical treatment equipment and accessories to perform the water treatment specified below. Maintain complete records of the treatment program for each system.

C. Contractor shall perform an analysis of the building water supply as a basis of the chemical treatment. Contractor shall provide the Owner with written instructions for chemical feeding bleed-off, blowdown control and testing procedures, provide all required chemicals, filters and testing during the guarantee period, and provide all required test kits.

D. Contractor shall maintain the following conditions in each system:

SYSTEMS	Dual Temperature System and Geothermal Heat Pumps System
ph	8.0 to 10.5
Inhibitor for Scale & Corrosion Cycles	---
Cycles*	---
Organic Growth	---
Buffered Nitrate	550 ppm
Chromate (Low)	
Molybdate	50 to 100 ppm
Sulfite	---
Sodium Nitrite	500 to 1000 PPM
Corrosion Inhibitor	50 to 100 PPM (as Molybdate) or 1000 to 1500 PPm sodium Nitrite
*Actual cycles of concentration to be determined from analysis of make-up water.	
Use Inhibited antifreeze supplied by Manufacturer	

E. Chemical Feeding Equipment: Provide chemical feeding equipment, as specified below, to introduce chemicals into each system only when the system is operating.

1. Closed Recirculating Systems

a. Five (5) gallon steel by-pass feeder installed across circulating pump suction and discharge lines, with tank and piping insulated using the same thickness and type of insulation as provided for the piping system. Provide filter. Unit shall contain quick opening cap and shall be suitable for working pressure of 175 psig. Tank shall be primed and finished in baked enamel paint.

2. Replace bypass feeder filter monthly during the entire 2-year warranty period.

F. Closed Recirculating Systems shall be filled and sufficient detergent and dispersant added to remove all dirt, oil, and grease. System shall be circulated for at least 48 hours after which a drain valve at the lowest point shall be opened and allowed to bleed while the system continues to circulate. The automatic make-up valve shall be checked to be sure it is operating. Bleeding shall continue until water runs clear and all detergent is removed. A sample of water shall be tested and if PH exceeds the PH of the make-up water, flushing shall be resumed. After chemical cleaning is satisfactorily complete, open the inlet and outlet valves to each coil and close the bypass valves. Also, clean all strainers.

G. Where glycol is specified or used, additional corrosion inhibitors should not be added without consulting the glycol manufacturer. The boilers shall be fired, maintaining a slow, rolling boil and preventing steam pressure from building during the process, while the surface of the water is continuously skimmed to remove impurities, the boiler manufacturer's recommended procedure shall be followed.

H. Before adding cleaned chemicals to the closed system, all coils should be isolated by closing the inlet and outlet valves by opening the bypass valves. Also clean all strainers.

2.23. ENERGY RECOVERY VENTILATORS

A. Provide and install ERV's (Energy Recovery Ventilators) as shown on contract drawings. ERV's shall be as manufactured by Venmar, Aaon, Daikin, or approved equal.

1. Energy Recovery Ventilator shall be Model Energy Pack as manufactured by Venmar or approved equal provided all specifications are met. Venmar equipment is used as the basis of design. Units shall be listed per UL 1812 and bear the UL label. Energy transfer ratings shall be in accordance with ASHRAE Standard 84 and ARI 1060. Wheels shall be ARI 1060 certified. Performance to be as scheduled on plans. Exhaust discharge and outside air intake shall not be located on the same side of the rooftop units.

B. Factory Testing and Quality Control

1. Standard Factory Tests: Units shall be factory run tested to ensure proper functioning of components. Fans shall be factory run tested to ensure structural integrity and proper rpm and shall be statically and dynamically balanced for continuous operation at the maximum rated fan speed and motor horsepower in accordance with AMCA 204. All electrical circuits shall be tested to ensure correct operation before shipment of unit. Units shall pass quality control and be thoroughly cleaned prior to shipment.

C. Unit Construction Description

1. General: Provide factory fabricated Air Handling Units with capacity as indicated on the schedule. The units consist of factory assembled components as shown on drawings, including but not limited to fan and motor assemblies, energy recovery device(s), all necessary dampers, hoods (outdoor units only), plenums, filters, drain pans, wiring, controls and other accessories as outlined in the schedule, enclosed in a single or multiple piece casing as shown on the mechanical drawings. Units shall be stand alone controlled, except where noted, with all control devices provided and wired for single-point power connection by the Manufacturer unless otherwise outlined in the schedule. Units shall have overall dimensions as indicated and fit into the space available with adequate clearance for service as determined by the Engineer. Tags and decals to aid in service or indicate caution areas shall be provided. Electrical wiring diagrams and Installation, Operation and Maintenance Instructions Manual shall be attached to the control panel access doors within each unit. Units shall be UL or ETL listed. Units shall be shipped in one piece or shall be split for shipment to accommodate freight as required, as shown on mechanical drawings.
2. Unit Base and Floor: Unit perimeter base shall be completely welded and constructed from (6” [152 mm]) structural tubing and shall accommodate curb or concrete pad installation as shown on drawings. Unit base floor shall be constructed from four-break formed steel panels, made from 14 gauge hot rolled steel (HRS). Floor panels shall be welded to each other, creating I-beams at each floor panel junction. Floor panel junctions shall be located at 14” increments (maximum) or less, in order to provide floor rigidity and support as required for internal components. Unit floor panels shall be welded to perimeter base frame steel tubing. Unit floor shall be insulated from underneath with 3”, R20 polyurethane closed cell spray foam and protected with 24 gauge galvanized steel liners. Unit floor construction shall include two-stage thermal break, using gasket between base floor framing and liners underneath and floor membrane on top. Unit base and floor shall be factory covered with top coat industrial grade membrane to ensure air- and water-tightness as well as walk-on grip. Floor membrane shall be high performance, sprayed, plural-component pure polyurea elastomer, based on amine-terminated polyether resins, amine chain extenders and prepolymers. Floor membrane shall be flexible, tough, resilient monolithic membrane with good water and chemical resistance and shall resist to temperatures up to 250°F. Floor membrane materials shall be free of solvents and VOC’s, shall be suitable for use in compartments handling conditioned air and shall comply with the requirements for the Standard for Heating and Cooling Equipment, ANSI/UL 1995, third edition, dated 02/18/2005, Section 5.10 and Section 18. Single wall floor construction with glued and pined insulation and no subfloor is not acceptable; non-insulated floor construction is not acceptable. Entire base frame is to be painted with a phenolic coating for long term corrosion resistance. Base frame shall be attached to the unit casing frame at the factory. When rigging, base frame deflection shall be less than 1/360 of the unit length. All major components shall be supported by the base without sagging or pulsating.
3. Rigging Provision – Single Piece Units: The unit base frame shall include lifting lugs located at the corner of the unit (and along the sides as required by design) and sized to allow rigging and handling of the units. Rigging shall be performed

using all lifting lugs at all times and in strict accordance with the instructions provided within the Installation, Operation and Maintenance Instructions Manual. Lifting lugs may be removed after rigging; however, bolts shall be set back in place after lug removal.

4. Rigging Provision – Multiple Piece Units: Units shipped in multiple sections shall be engineered for field assembly. The unit section base frame shall include lifting lugs located at the corner of the unit (and along the sides as required by design) and sized to allow rigging and handling of the units. Rigging shall be performed using all lifting lugs at all times and in strict accordance with the instructions provided within the Installation, Operation and Maintenance Instructions Manual. Peripheral lifting lugs may be removed after rigging; however, bolts shall be set back in place after lug removal. Lifting lugs located along a section side corresponding to a unit section split shall be removed without bolts being set back in place afterwards. Units shall be provided with all necessary gaskets, caulking, hardware and instruction for assembly on site by Installing Contractor. Compression points shall be provided at the base frame, along the sides at 18” increments and at the top for aligning and joining section splits.

5. Unit Casing: Unit wall and roof rigid frame shall consist of 16 gauge pre-painted galvanized formed steel corner posts and 16 gauge G90 galvanized formed steel (1” x 2”) intermediate frame posts, providing stable construction allowing for removal of any panel without affecting unit structural integrity. Exterior casing panels shall be attached to the gasketed (1” x 2”) steel frame with corrosion resistant fasteners. Air Handling Unit casing shall be of the no-through-metal design. Casing shall incorporate insulating thermal breaks as required so that, when fully assembled, there is no path of continuous unbroken metal to metal conduction from inner to outer surfaces. Provide necessary support to limit casing deflection to L/200 of the narrowest panel dimension. If panels cannot meet this deflection, additional internal reinforcing is required. Units shall be designed for outdoor or indoor installation as indicated on the schedule. Indoor units weatherized for outdoor use are not acceptable. Outdoor units shall have a double sloped roof with 3% minimum roof pitch to prevent water accumulation, rain gutters above all access doors and roof joint seams of the T-shape construction, with minimum height of 1”, metal strip sealed and encapsulated. Outdoor units shall be designed to resist snow, ice and wind loads, and if provided with weather hood(s), equipped with birdscreen and rain gutters. Indoor units shall have a flat roof. Hoods shall be shipped loose for field assembly. Internal partition on dual air tunnel units shall be insulated and constructed in the same manner and thickness as the unit cabinet outer liners. All panel seams shall be caulked and sealed for an air-tight unit. AHU exterior casing envelope shall be suitable to attain a maximum air leakage rate equal to 1.0% of design CFM when unit is operating at design static pressure.
Unit outside surfaces shall be made of pre-painted steel unless otherwise specified. All galvanized steel surfaces requiring paint shall be made of satincoat finished galvanized steel of the specified gauge(s). All galvanized steel surfaces without any paint shall be made of galvanized steel of the specified gauge(s).

a. Options:

i. Corrosion resistant exterior paint finish complete with one coat of air dried epoxy paint, which shall withstand 1,000 hours of

salt spray as per ASTM B-117.
ii. Color selection shall be by the Architect.

6. Double Wall Construction: Units shall entirely be made of double wall construction. Single wall construction with coated insulation is not acceptable. Exposed insulation edges in the airstream are not acceptable. Unit panels shall be made of 18 gauge galvanized steel outer liners and 24 gauge galvanized steel inner liners.
7. Insulation: Unit wall and roof panels shall be insulated with 3” thick, R12.5, 1.5 lb./cu. ft. non-compressed fiberglass insulation. Unit internal partition (dual air tunnel units) shall be insulated with 2” thick, R8.3, 1.5 lb./cu. ft. non-compressed fiberglass insulation. Insulation shall meet the erosion requirements of UL 181 facing the airstream and fire hazard classification of 25/50 (per ASTM-84 and UL 723 and CAN/ULC S102-M88). All insulation edges shall be encapsulated within the panels. All perforated sections shall have insulation with black acrylic coating.
8. Access Doors: Full size access door(s) allowing for periodic maintenance and inspections shall be provided for all serviceable components as shown on the plans. Removable panels are not acceptable. Doors shall be solid double wall insulated construction. Insulation shall be the same as unit panels. Both the inner and outer liners shall be made of the same material as unit cabinet outer liner construction. The door hinge assembly shall be die cast zinc with stainless steel pivot mechanism, completely adjustable. Hinges shall allow doors to open at 180° with no shear effect on the hinge side of the perimeter gasket. The door frame shall be extruded aluminum with a built-in thermal break barrier and full perimeter gasket. The door gasketting shall employ a double seal comprising of an adhesive neoprene compressible foam gasket on the outer door panel and an “automotive style” neoprene bulb gasket fixed onto the inner door frame for out-swing doors, “rippled” foam for in-swing doors. There shall be a minimum of two heavy duty cast, UV rated, nylon handles per door. Door handles shall be operable from both inside and outside of the unit. On all access doors where moving parts could cause injury, an ETL, UL 1995 and OSHA approved tool operated safety latch shall be provided.
Note: If Manufacturer cannot provide thermal break door design it must be noted as an exception on the bid.

a. Options:

i. Doors shall open against pressure.
ii. Access doors all sections shall be equipped with hold-open device.
iii. Access doors all sections shall be equipped with handle inter-linkage system to be able to open each door by operating only one handle.

9. Condensate/Drain Pans: IAQ style drain pans shall be provided as shown on the drawings. Drain pans shall be fabricated from 18 gauge stainless steel, except under coils, where drain pans shall be fabricated from 14 gauge stainless steel. All drain connections shall be piped and trapped for proper drainage. Drain pans shall be sloped at a minimum of 1.5% with a threaded drain pipe connection ending through the side of structural base frame. Drain pipe shall be schedule 40,

1¼" nominal, MPT stainless steel pipe. All drain pan corners shall be welded.

10. Enthalpy Wheel Heat Exchanger:

a. Quality Assurance

i. The wheel shall bear the AHRI 1060 Certified label. Wheels tested in independent laboratories, whether according to AHRI Standard 1060 or not, are not acceptable unless actually certified by AHRI. Wheel Manufacturer membership in AHRI is not an acceptable substitute for AHRI Certified™ performance.
ii. The energy recovery wheel shall be a UR recognized component and bear the UR label.
iii. The energy recovery wheel shall comply with the requirements of UL 723. The media shall have flame spread index (SPI) of less than 25 and a smoke developed index (SDI) of less than 50 when rated in accordance with ASTM E84.
iv. The energy recovery wheel shall comply with the IBC Certification and OSHPD Seismic Qualifications.

b. Performances – Effectiveness, Pressure Drop, Exhaust Air Transfer Ratio (EATR) and Outdoor Air Correction Factor (OACF)

i. Sensible, latent and total effectiveness along with pressure drop, EATR and OACF ratings, shall be clearly documented in the AHRI 1060 Certified Directory (http://www.ahridirectory.org/ahridirectory).
ii. To reduce fan operating costs, the energy recovery wheel shall not exceed an OACF of 1.15 for rotors up to 70" and 1.08 for rotors up to 120" at 5" w.c. pressure differential when no purge is used. The result shall be clearly shown in the AHRI 1060 Directory.

c. Rotor Media and Desiccant

i. The rotor media shall be made of 2 mils minimum thickness aluminum. The media shall be coated to prohibit corrosion and shall be suitable for seacoast applications. Non-metallic substrates made from paper, plastic, synthetic or glass fiber media are not acceptable.
ii. All surfaces shall be coated with a non-migrating desiccant specifically developed for water transfer in vapor phase. Etched or oxidized surfaces are not acceptable.
iii. Desiccant must be a polymer hygroscopic or 3 angstroms molecular sieve (3A).
iv. Desiccant shall be bactericide and non-corrosive.
v. The rotor shall be constructed of equal width, alternate layers of corrugated and flat aluminum sheet material to create a flat and smooth surface and ensure laminar flow thus preventing any dust or particle accumulation inside the rotor.
vi. Corrugation pattern shall be of closed triangular shape to prevent any cross leakage between airstreams. Open type corrugation or

embossments, since they increase fan operating costs, are not acceptable.

vii. Dry particles up to 800 microns shall freely pass through the media to minimize air pressure drops and prefiltering requirements.

viii. Furnish spare rotor belt.

d. Seals

i. The rotor shall be supplied with AirLoop™ labyrinth seal facing the media, polymer contact seal along the depth of the wheel and S-type labyrinth seal along the wheel's periphery. Wheels using less effective seals like brush seals or standard 4 pass labyrinth seals are not acceptable.

ii. The AirLoop labyrinth seals shall be installed with no gap between the seal and media. Labyrinth seals that require an installation gap or seals that will damage the media if they come in contact with it are not acceptable.

iii. All seals shall be designed to withstand pressure differentials of up to 10" w.c.

iv. The AirLoop labyrinth seals shall be factory adjusted. Field adjustments shall be possible using common tools.

e. Options:

i. Wheel shall be segmented to allow removal in pieces.

ii. Wheel shall be provided with a field adjustable purge section.

11. Heat Pipe Heat Exchanger: Energy transfer ratings shall be AHRI Certified to Standard 1060 and bear the AHRI certification seal for AHRI Air-to-Air Energy Recovery Ventilation Equipment Program based on AHRI 1060. Ratings in accordance with AHRI 1060 without certification are not acceptable. Heat exchanger shall be tested in accordance with ASHRAE 84-91. Heat pipe shall transfer heat between airstreams in a counter flow configuration. Core shall be 1" ID seamless, integrally finned aluminum 1,350 tube with a 0.166" minimum wall thickness. The maximum center-to-center spacing shall be 2-1/8" for tubes and 1-7/8" for rows. Fins shall be extruded from and integral with the tube wall and shall have a 0.017" minimum fin thickness. Fin density shall be 11 per inch. Fin surface from the root to the tip of the fin should have a minimum of 0.437" between fin heights. Expanded and or wrapped fin and tube design construction is not acceptable. Tube shall have an integral internal circumferential capillary wick structure. Capillary structure shall not interfere with tube wall integrity. Tubes shall be individually processed, charged with refrigerant, hermetically sealed and factory tested. Heat pipe frame shall be fabricated from galvanized steel. Intermediate tube supports shall be furnished if required. A partition made from galvanized steel shall isolate the two airstreams and not allow cross-contamination. End covers made of galvanized steel shall be provided to protect tube ends. A drain pan shall be provided in the exhaust section for condensate collection.

a. Options:

i. Heat pipe shall be coated with heresite corrosion resistant coating on supply and exhaust sides.

ii. Drain pans shall be provided on each side of the heat pipe for condensate collection or servicing.

12. Unit Fans: Fan assemblies shall be designed for heavy duty industrial applications. All fans shall meet the airflow performance specified and shall not exceed the break horsepower or sound power levels specified on the mechanical equipment schedule. Fan performance shall be based on testing and be in accordance with AMCA 210 for performance and AMCA 300 for sound. Fans shall be selected for stable operation, at least 20% under the first critical speed of the fan, with a steep pressure/volume curve. Fan shaft shall be turned, ground and polished solid steel, finished off with a corrosion resistant coating and rated at maximum rpm below critical speed. Fan wheel and sheaves shall be keyed to the shaft. Fan drives shall be designed for a 1.3 service factor. Pulleys shall be factory mounted with final alignment and belt adjustment completed before unit start-up. Motor (driver) and fan (driven) pulleys shall be of fixed pitch. Bearings shall be heavy duty, grease lubricated, self-aligning ball or pillow block type, selected for a minimum average bearing life (L-50) in excess of 200,000 hours at maximum operating speed in accordance with AFBMA 9 Standards. Inlet cones shall be precision spun or die formed. Inlet cones shall be aerodynamically matched to the wheel side plate to provide streamlined airflow in the wheel and ensure full loading of the blades. Fan and motor assemblies shall be mounted inside the unit casing, on a base equipped with 1” deflection spring vibration isolators and supplied with flexible connections. Fans shall be balanced per ANSI/AMCA 204-96 fan application category BV-3 using a digital signal analyzer at the design rpm with belts and drives in place to a vibration velocity less than or equal to 0.157” per second measured horizontal and vertical at each bearing pad. Vibration amplitudes are in inches per second-Peak. All values are filter-in at the fan speed. Removable shipping restraints shall be provided to protect the fan, motor and base during shipment.

a. Plug Fan (PF) SWSI Fans

i. Fan shall be single width single inlet arrangement 3 plenum fan. Fan blades shall be hollow airfoil in shape, welded to the center and wheel side plates. Fan bearings shall be heavy duty type. Rigid support for the inlet bearing must be removable for access to the wheel. Inlet cone shall be precision spun.

b. Motors shall be invertor duty rated, heavy duty, constructed to NEMA Standard MG 1, general purpose, continuous duty, Design B. Temperature rating shall be 122°F, maximum temperature rise at 104°F [40°C] ambient for continuous duty at full load (Class B Insulation). Motors shall be T-frame mounted on an adjustable steel base that allows for belt alignment and tensioning, within the unit casing. All motors shall be tested to IEEE Standard 112 test method B and rated per NEMA MG1, Part 31 “Inverter Fed Motors”. Motor bearings shall be ball or roller type with inner and outer shaft seals, grease lubricated and designed to resist thrust loading where belt or other drives produce lateral or axial thrust in motors. All motors shall be specifically designed to meet or exceed all EPAct requirements for energy efficiency and include Class F insulation. Motor shall be of minimum size as indicated in the equipment schedule, 1,800 rpm, open drip proof (ODP) and have a 1.15 service factor. Motor torque shall efficiently accelerate the drive loads. Unless indicated, motor shall not operate in the service factor range.

c. Provide shaft grounding rings for all variable frequency drive motors.

d. Variable Frequency Drives (VFDs)

i. Each variable air volume supply and exhaust air fan shall be provided with separate variable frequency drives with bypass. Drives shall be factory mounted with adequate ventilation provided. The variable frequency drive shall convert input voltage (with +/−10% tolerance), three-phase, 60 Hz (+/−2 Hz.) utility power to adjustable voltage/frequency, three-phase, A–C power step less motor control from 5% to 105% of base speed. The variable frequency drive shall produce an adjustable A–C voltage/frequency output of complete motor speed control and an input power factor near unity over the entire speed range. The VFD shall be automatically controlled by a control signal. The VFD shall be self-contained, totally enclosed in a NEMA 1 ventilated cabinet and capable of operation between 0°C and 40°C. The VFD shall be UL listed. Components used in all options shall be UL listed. The VFD shall have a hand/off/auto operator switch, drive switch with run or stop command and panel mounted digital display capable of indicating unit status, frequency and fault diagnostics. Variable frequency drives shall comply with all requirements specified under Part 2 "Variable Speed Drives" of this specification section.

e. Fan assemblies shall be provided with the following options:

i. Fan drives shall be equipped with adjustable motor sheaves.
ii. Extended lubrication lines with copper tubing mounted on the fan assembly access side.
iii. One spare set of fan belts.
iv. Motors shall be premium efficiency.
v. Motors shall be inverter duty rated.

13. Dual Temperature Water Coils – General Information: Coils shall be submerged in water and tested to a minimum dry air/nitrogen pressure of 300 psig standard copper tube coils. Coils shall display a tag with the Inspector's identification as proof of testing. Tubes shall have a nominal thickness of 0.020" unless otherwise specified. Fins shall be made of 0.0075" thick aluminum unless otherwise specified. Tubing, return bends and headers shall be made of seamless UNS 12200 copper meeting ASTM B75 and ASTM B251 Standards. Coil return headers shall be equipped with factory installed 1.2" FPT air vent connections placed at the highest point available on the face of the header (except for evaporator coils). Casings and endplates shall be made of 16 gauge galvanized

steel, meeting ASTM A527 Standard unless otherwise noted. Double flanged casings on the top and bottom of finned height shall be provided to allow for coil stacking. Piping, control valve and valve operator shall be supplied and installed by the Mechanical Contractor and ATC Subcontractor.

14. Hydronic Coils: Hydronic coils shall be designed to withstand 250 psig maximum operating pressure and a maximum water temperature of 300°F for standard duty copper tube coils. Standard construction fluid MPT connections shall be made from red brass meeting ASTM B43 Standard or Schedule-40 steel pipe as a minimum. Provide intermediate drain pans on all stacked cooling coils. The intermediate pan shall drain to the main drain pan through a copper downspout.
    Fins shall be made of 0.0075” thick aluminum and mechanically bonded to copper tubes.

15. Filters: Provide filters of the type indicated on the schedule. Factory fabricated filter sections shall be of the same construction and finish as the unit. Outside and exhaust air inlets shall be equipped with galvanized steel racks that permit filter slide out removal (side access) for units equal or less than 78” tall and universal holding frames with upstream access (face loading) for units taller than 78”. Face loaded pre and final filters shall have Type 8 frames as manufactured by AAF, FARR or equal. Side service filter sections shall include hinged access doors. Internal blank-offs shall be provided by the air unit Manufacturer as required to prevent air bypass around the filters. The filters shall be as manufactured by Farr, Purolator, AAF or equal. Filters shall be in compliance with ANSI/UL 900: Test Performance of Air Filters. Filter air velocity shall not exceed 500 fpm through each filter bank. Units shall be equipped, to a minimum, with 2” thick, MERV 13 pleated filters.

    a. High Efficiency Rigid Filters

        i. Filters shall be 12” deep high performance, pleated, totally rigid and totally disposable type. Each filter shall consist of high density glass fiber media, media support grid, contour stabilizers and enclosing frame. Filter media shall be laminated to a non-woven synthetic backing to form a lofted filter blanket. The filter media shall have an average efficiency of 85% (MERV 13). The media support shall be a metal grid with an effective open area of not less than 96%. The metal grid shall be bonded to the filter media to eliminate the possibility of media oscillation and media pull-away. The metal grid shall be formed in such a manner that it affects a tapered radial pleat design. The grid shall be designed to support the media both vertically and horizontally. Filters shall be listed Class II under UL Standard 900. Filters shall be tested per ASHRAE Standard 52.1-76. Contour stabilizers shall be permanently installed on both entering air and exit airsides of the filter media pack to ensure that the tapered radial pleat configuration is maintained throughout the life of the filter. The filter shall be capable of withstanding a 10” w.g. pressure drop without noticeable distortion of the media pack. The enclosing frame shall be constructed of galvanized steel. It shall be constructed and assembled in such a manner that a rigid and durable enclosure for the filter pack is affected. The periphery of the filter pack shall be continuously bonded to the inside of the enclosing frame, thus eliminating the possibility of air bypass. The enclosing frame shall be equipped with protective diagonal support members on both the entering air and air exit sides of the filters.

16. Dampers: Unit shall be equipped with all necessary dampers required for the system as shown on the mechanical drawings. Dampers shall be designed for operating temperatures between −40°F and 212°F. Air leakage through a 48” x 48 damper shall not exceed 10.3 cfm/sq. ft. against 4” w.g. differential static pressure at standard air condition. Standard air leakage data to be rated in accordance with AMCA certified rating program. Outside air dampers shall be opposed blade motorized and exhaust air dampers shall be parallel blade motorized type. For other dampers, see Manufacturer's recommendations. Damper actuators drive voltage shall be with 24 VAC for 2 position or 0–10V for modulation. Flat or formed metal blades are not acceptable.
Damper construction shall be as follows: damper frame shall be of extruded aluminum or galvanized steel; damper blades shall be of extruded aluminum; dampers shall be of opposed blade type or parallel blades where indicated; damper blade ends shall be sealed with neoprene edge seals with bottom and top blade wiper seals.

    a. Provide the following:

        i. Outside air damper (motorized, spring return)
        ii. Exhaust air damper (motorized, spring return)

17. Rain Hoods: Rain hoods shall be fabricated from same material as unit casing with ¼” wire mesh inlet screen. Hoods sized to minimize moisture carry over and shall be same color as unit.
18. Roofcurbs: Roofcurb shall be supplied by the unit Manufacturer for field assembly. Manufacturer’s curb shall be standard double wall, 18” height, 2” thick fiberglass insulation. Curb shall consist of formed 18 gauge galvanized steel sections.

    a. Options:

        i. Pitch roofcurb shall match building roof.
        ii. Curb can be provided with wood nailor.
        iii. Curb shall be arranged so all hydronic pipes enter unit within roof curb to protect the same from freezing.

D. Electrical Power and Controls

1. All wiring and electrical connections shall be of copper wires, copper bus bars and copper fittings throughout. Power supply terminals shall be identified with permanent markers.
2. All high voltage wiring conduit shall consist of flexible metal conduit. All low voltage and signal wiring shall consist of Belden cable.

    a. All high and low voltage wiring shall be run in Liquidtite flexible metal conduit.

3. When unit section splits are present, low voltage wiring shall be split using quick connectors for quick and easy field installation. Additionally, for each set of quick connector, the male branch in one unit section and the corresponding female branch in the next unit section shall be identified with the use of a color coded or numbered label. At each high voltage line split, a junction box shall be provided in one of the sections; the wiring in the section where the junction box is located and the matching wiring in the next section shall be identified with the use of a color coded or numbered label.
4. The unit shall feature a mounted permanent nameplate displaying, at a minimum, the Manufacturer, serial number, model number, date of manufacture and current and voltage readings. The unit must have an ETL or UL Listing and bear the appropriate mark.
5. A recessed integral electrical control compartment shall be furnished on the end of the unit. The compartment shall be constructed to NEMA 3R requirements for outdoor units, provided with a hinged access door and a locking device. All components, except those not mounted directly in the unit, shall be factory mounted and wired to a labeled terminal strip. All components shall be identified using printed self-adhesive labels, consistent with the numbering used in the wiring diagrams. Control components shall include, but are not limited to, single-point connection power distribution block, sub and control circuit fuses or circuit breakers, control transformers, motor starters and overloads for single-speed operation. The control system shall be factory mounted in the control compartment and shall be a stand alone microprocessor-based Direct Digital Control system, with necessary sensors and interfaces to monitor and operate all functions as outlined in the equipment/control schedule, flow schematic, sequence or required for complete unit operation. A unit mounted intelligent programmable interface device shall be included for communication, display and setpoint control. Control panel compartment heaters and thermostats or cooling fans with grilles or registers shall be provided if control panel components cannot be protected from their minimum or maximum ambient temperature ratings. For automatic unit start-up an external dry contact must be provided by others (ex: building management system (BMS), BACnet, time clock, etc.). The DDC controller shall be factory programmed and factory run tested prior to shipment to verify functions and logic.
6. A flow schematic with sensor and component identification and location, interlocks and sequence of operation shall be included with submittals.
7. A wiring schematic and a bill of materials shall be completed in ladder/logic format, with component labeling according to line numbers, once a release for production has been received. The wiring schematic, bill of materials and flow schematic shall be included within the units control compartment.
8. The unit shall be provided with fluid furnished and installed, Direct Digital Control system, including all provisions. All safety controls shall be manual reset.
9. The units shall be provided with the following features:

   a. Unit shall be provided with a fused disconnect or circuit breaker mounted within the control enclosure with a door interlocked handle (weatherproof) on the exterior.

i. The unit Manufacturer shall provide a field start-up by a qualified Factory Technician (to be covered as part of the unit pricing from the Manufacturer).

ii. The control system with necessary sensors and interfaces shall be field supplied, programmed, mounted, wired and run tested by the Control Contractor. The Control Contractor shall coordinate sensors, interfaces, mounting locations and logic with the unit Manufacturer. The control system shall be mounted in the control compartment.

iii. Unit shall have a 120 VAC GFI receptacle for a separate 120 volt power supply. Electrical power wiring shall be provided by under Division 26.

iv. Fan motors shall have variable frequency drive with drive bypass and line reactors.

E. Demand Control Ventilation Components:

1. Energy recovery ventilator fans shall be controlled by a variable frequency drive, as manufactured by Yaskawa or approved equal. Outdoor air and exhaust air fans shall be controlled simultaneously to maintain desired building pressure. Variable frequency drive shall be pre-programmed at the factory and shall assure that minimum outdoor air and exhaust air volumes are always maintained. The variable frequency drive shall be factory mounted in the unit cabinet and wired.

2. Energy recovery ventilator shall be equipped with demand control ventilation capabilities that enable the varying of outdoor air and exhaust air volumes based on building occupancy. A sensor shall be located in the exhaust air stream to monitor average CO2 levels of the occupied spaces. A variable frequency drive shall receive a 0-10 volt signal from the CO2 sensor and control the outdoor air volume to maintain a maximum of 1,000 ppm of CO2 in the occupied space. Outdoor air and exhaust air fans shall be controlled simultaneously to maintain desired building pressure. Variable frequency drive shall be pre-programmed at the factory and shall assure that minimum outdoor air and exhaust air volumes are always maintained. The sensor and variable frequency drive shall be factory mounted and wired. Additional space CO2 sensors shall be required (refer to plans for quantity and location) and interlock with ERV and demand controlled ventilation.

3. Furnish each energy recovery ventilator with the following:

   a. Supply air fan variable frequency drive.
   b. Exhaust air fan variable frequency drive.
   c. Phase loss protection.

4. The CO2 sensors shall modulate air flow rates in a linear fashion from minimum to maximum based on CO2 measurement and reset schedule. Coordinate with ATC Subcontractor.

F. Extra Materials:

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

2. Filters: Furnish one set of each type of filter.
3. Fan Belts: Furnish one set of link type belts for each belt drive fan in energy recovery ventilator.
4. Wheel Belts: Furnish one set of belts for each belt driven energy wheel.

G. BAS Interface: Field-installed hardware and software to enable the BAS to monitor, control, and display Variable Frequency Drives status and alarms. Allows VFD to be used with an external system within a multidrop LAN configuration; settings retained within VFC's nonvolatile memory.

1. Network Communications Ports: Ethernet and RS-422/485.
2. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet; protocols accessible via the communications ports.

2.24. HOSE KITS

A. Provide hose kits at all water source heat pumps of the minimum size as scheduled on the Contract Drawings or as requird to meet pressure drop limitation whichever is greater. Hose kits shall be provided for all water connections to water-to-air and water-to-water heat pumps. Hoses shall be Metroflex Elasto-Flex, Griswald, Hastings, or approved equal.

B. Furnish hose kits with all necessary brass fittings for connections of heat pumps to runouts as detailed on drawings. Tubing shall be nontoxic polythene tube with galvanized or stainless steel, steel braid and rust resistant connectors - male and female swivel.

C. Hose shall be constructed for 185 psig working pressure and 740 psi burst pressure, -20 degrees F to 230 degrees F temperature range.

D. Hose lengths shall be 12 inches, with MPT adapter and pipe reducer fitting.

E. At Contractor's option hose kits may be combined with strainers, valves, P/T ports, unions, auto flow valves, and control valves into a factory assembly. Hose kit total pressure drop for entire assembly including all devices and both hoses shall not exceed 10 feet at scheduled flow rate. However, type of control valve specified must be provide by the ATC subcontractor.

F. Coordinate with Division 23 Section, Instrumentation and Controls of HVAC and Plumbing Systems regarding 2 position valves and actuators if hose kits are to be furnished under this section.

2.25. WATER TO AIR GROUND SOURCE HEAT PUMPS (HORIZONTAL SUSPENDED UNITS)

A. Provide water-to-air ground source heat pumps of the size, capacity, efficiency, and electrical characteristics as indicated on the Contract Drawings. Units shall be Model GEHA or GEVA as manufactured by Trane, Daikin GSV/GSH, Enfinity as manufactured by McQuay, Water Furnace, Florida Heat Pump, Climate Master, Bryant, Johnson Controls, Geoexcel, Geocomfort, or approved equal. Unit dimensions shall not exceed that which is required for proper installation above ceilings allowing for service and maintenance.

B. Units shall be ARI 330 certified for use as extended range heat pumps for geothermal closed loop applications.

C. Equipment shall be completely assembled, piped, internally wired and test operated at the factory. Units shall be both ETL and ISO-ARI 13256-1 listed and labeled prior to leaving the factory. Service and caution area labels shall be also be placed on the unit in their appropriate locations.

D. Cabinet:

1. The cabinet shall be constructed of galvanized steel, with exposed edges rounded. Service to the refrigerant and controls shall be provided through a single access panel at the front of the unit.
2. Insulation for the internal parts and surfaces exposed to the conditioned air stream shall be made of moisture resistant insulation.
3. The insulation shall be ½ inch thick dual density bonded glass fiber. The exposed side shall be a high density erosion proof material suitable for use in airstream up to 4500 feet per minute (FPM). Insulation shall meet the Underwriters Laboratories Fire Hazard Classification:

    a. Flame Spread = 20
    b. Fuel Contributed = 15
    c. Smoke Developed = 0

4. Access for inspection and cleaning of the unit drain pan, coils and fan section shall be provided. The unit shall be installed for proper access. Procedures for proper access inspection and cleaning of the unit shall be included in the maintenance manual.
5. Furnish units with Merv 8, 1 inch thick, pleated disposable air filters and a factory installed combination filter rack/return air duct collar. The filter rack shall be field convertible to bottom filter removal. Where return air devices are indicated to be provide with filters and filter racks, do not provide filters/filter racks with heat pumps.
6. Filter racks shall be gasketed and air tight to prevent leakage.

E. Sound Attenuation:

1. Sound attenuation shall be applied as a standard feature in the product design.
2. The sound reduction package shall include a compressor discharge muffler, vibration isolation to the compressor and water-to-refrigerant coil, unit base stiffeners, insulated metal compressor enclosure, and a second stage of vibration isolation to the compressor and water-to-refrigerant base pan.
3. The unit shall be tested and rated in accordance with ARI 260P.
4. Furnish and install sound attenuation blankets on all compressors to reduce noise.

F. Refrigeration System

1. The unit shall include a high efficiency scroll compressor. External vibration isolation shall be provided by rubber mounting devices located underneath the mounting base of the compressor. A second isolation of the refrigeration assembly shall be supported under the compressor mounting base. Where

scheduled provide multistage units.

2. Internal thermal overload protection shall be provided. Protection shall be provided against excessive discharge pressure operation by means of a high pressure switch. Loss of charge protection shall be provided by a low pressure switch.
3. Heat Exchanger: The water-to-refrigerant heat exchanger shall be of a high quality coaxial coil for maximum heat transfer. The cupro-nickel coil shall be deeply fluted to enhance heat transfer and minimize fouling and scaling. The coil shall have a working pressure of 450 psig of both the refrigerant and water sides. The factory shall provide rubber isolation to the heat exchanging device to enhance sound attenuation.
4. Reversing Valve: The reversing valve shall be a pilot operating sliding piston type with replaceable encapsulated magnetic coil. This valve shall be energized in cooling.
5. Tubing: The refrigerant tubing shall be of 99 percent pure copper. This system shall be free from contaminants and conditions such as drilling fragments, dirt and oil. All refrigerant and water lines shall be insulated with an elastomeric insulation that has a 3/8 inch thick wall wherever air is introduced to the assembly.
6. Refrigerant Metering: The equipment shall be provided with a (TXV) thermal expansion valve to allow operation of the unit with entering fluid temperature from 25 degrees F to 125 degrees F.
7. Schrader Connections: The refrigerant access ports shall be factory supplied on the high and low pressure sides for easy refrigerant pressure or temperature testing.
8. Refrigerant type shall be R-32 or R-454B. Units shall be shipped fully charged with the appropriate refrigerant and oil.
9. All refrigerant piping and heat exchangers shall be factory insulated to minimize heat transfer and eliminate condensation.

G. Air-to-Refrigerant Coil:

1. The air-to-refrigerant coil shall contain copper tubes mechanically expanded into evenly spaced aluminum fins. All coils are to be leak tested. Pressure testing shall be performed at 450 psig operating pressure and the leak test at 125 psi operating pressure with helium. In addition, the tubes are to be completely evacuated of air prior to shipment.
2. The refrigerant coil distributor assembly shall be of orifice style with round copper distributor tubes. The tubes shall be sized consistently with the capacity of the coil. Suction headers shall be fabricated from rounded copper pipe.
3. A thermostatic expansion valve shall be factory selected and installed for a wide range of control.
4. Air conditioned condensate pan shall slope a minimum of ¼" in two (2) directions and shall be fully insulated and constructed of corrosion resistance materials.

H. Drain Pan

1. The condensate pan shall be constructed of high impact plastic to prevent corrosion and sweating. The bottom of the drain pan shall be sloped on two planes to provide complete drainage of water from the pan. The unit shall be

supplied with a standard solid-state electronic condensate overlow protection. Water level detection shall comply with U.L. 508. Drain pan shall be insulated to prevent condensation.

I. Electrical

1. The factory or field tested and installed control box shall contain all necessary devices to allow heating and cooling operation of the equipment to occur from a remote wall thermostat or zone sensor. Thermostats and zone sensors shall be furnished under Division 23 Section, Instrumentation and Controls of HVAC and Plumbing Systems. The devices shall be as follows:

   a. 24 VAC Energy Limiting Class II, 50VA breaker type transformer (minimum)
   b. 24 VAC contactor for compressor control
   c. 18 Pole terminal strip located inside the control box behind the service access panel. This terminal strip shall be used for low voltage (thermostat/zone sensor) connections.
   d. An electrically operated safety lockout relay shall prevent cycling of the compressor during adverse conditions of operation. This device shall be reset either at the remote thermostat/zone sensor, or by cycling power to the unit.
   e. A high pressure switch shall protect the compressor against operation at refrigerant system pressure in excess of 395 psig.
   f. A low pressure switch shall prevent compressor operation under low charge or catastrophic loss of charge situations.
   g. Factory installed wire harness.
   h. Provide factory wired disconnect.

J. Controls

1. Terminal Unit Controller: This system shall utilize ATC Contractor furnished and mounted DDC controls for operation of a complete building system on a Comm 4 link. The TUC control package shall include a 75 VAC transformer. The controller shall provide anti-short cycle compressor protection, random start, heating/cooling status, occupied/unoccupied mode, as well as fan and filter status options. Optional wiring from the factory for condensate overflow shall be provided. Five LEDs (light emitting diodes) shall also be included for diagnostics of the equipment.
2. BAS Communication Interface: There shall be a BAS Communication Interface that ties into the Unit Control Processor. This system shall provide the following diagnostic information: Communication Network Status at each unit, Mode of Operation, System Cooling and Heating Setpoints, Local Cooling and Heating Setpoints, Compressor Operational Status, Reversing Valve Status, Zone Temperature, Discharge Air Temperature, Leaving Water Temperature, Fan Mode, Fan Status, and Compressor Fault Status.
3. Controls: Factory or Field wired, control shall perform the following:

   a. Random start of all water source heat pumps.
   b. Anti-short cycle protection shall prevent rapid cycling of the compressor during changeover from heat to cooling or vice-a-versus.

c. A two wire twisted pair shall be able to perform the following functions when connected to the control system: load shedding. Emergency shutdown. Time of day scheduling. Alarm shutdown as a result of: Loss of water flow. High water temperature. Low water temperature.

d. Delays shall prevent the reversing valve from changing status against large differentials in pressures within the hermetically sealed system.

e. A single common alarm output shall be provided to: Initiate an alarm at the EMS.

f. The control system shall monitor the current to the compressor contactor via a high pressure switch. If this switch activates and causes a loss of current to the contactor during a compressor "on mode", then the control system shall shutdown the water source heat pump and cause the common alarm output to be energized.

g. The controls shall monitor the low refrigerant pressure and if it activates during the compressor "on mode", then the controls shall shutdown the water source heat pump and cause the common alarm output to be energized.

h. A freeze protection thermostat shall sense leaving water temperature. If the water temperature falls below the set point, the controls shall shutdown the water source heat pump and cause the common alarm output to be energized.

i. The control system shall visually display the following alarm conditions via the BAS. High pressure, Low refrigerant temperature, Condensate overflow.

j. The control system shall require a manual reset to restore normal operation after any of the following alarm conditions: high pressure, low refrigerant temperature, or condensate overflow.

k. The control system shall visually display the status of the water source heat pump at all times. Definition of all possible status shall be indicated at the BAS.

l. The control system shall provide a field service input for diagnostic purposes.

m. Condensate overflow switch shall be provided to lock out the compressor operation when a high level of water is detected.All water lines, refrigerant lines, hot gas lines and condensate lines shall be fully insulated with 1-inch closed cell insulation.

4. DDC terminal unit controller for each heat pump shall be furnished by the Automatic Temperature Control Contractor for factory installation by the water to air ground source heat pump manufacturer or field installation by the Automatic Temperature Control Contractor.

5. The DDC terminal unit controller shall be shipped by the Automatic Temperature Control Contractor to the water to air ground source heat pump manufacturer for installation at the factory. At Contractor's option, the DDC terminal unit controllers may be installed in the field.

6. The cost of factory or field mounting, wiring, and any factory testing and programming of the terminal unit controller shall be included by the water to air ground source heat pump manufacturer.

7. The Automatic Temperature Control Contractor shall coordinate with manufacturer to ensure the delivery of factory or field installed controls and

proper installation according to the project schedule.

K. Motors: The motors shall be multi-speed permanent split capacitor type with thermal overload protection. Where required, standard static or high static shall be selected and wired from the factory to match performance criteria. The motor shall contain a quick-disconnect plug and permanently lubricated bearing.

L. Fans: The fans shall be placed in a draw-through configuration. They shall be constructed of corrosion resistant galvanized material.

M. Orifice Ring: Removal of the motor and fan wheel shall be made with the assistance of factory provided orifice ring device. This device shall attach the wheel and motor to the fan housing in one assembly providing single side service access.

N. Warranty: The unit shall be warranted by the manufacturer against defects in material and factory workmanship for one year. The refrigerant circuit including motor-compressor, expansion device, all heat exchangers in contact with refrigerants, and reversing valve (less solenoid coil) shall be warranted for four additional years.

O. Supply Fan Control: Provide fan speed switch, dial, or auxiliary transformer to allow field adjustment of supply air fans during testing/balancing. Supply fan airflow rate shall be limited such that airflow rate shall operate within manufacturers required range to prevent unstable operation and/or freezing of evaporator coil. Clearly label supply fan control and provide directions for proper use of the same.

2.26. WATER TO WATER GROUND SOURCE HEAT PUMPS

A. Provide water-to-water ground source heat pumps of the size, capacity, efficiency, and electrical characteristics as shown on the contract drawings. Units shall be WaterFurnace Model NXW, Johnson Controls Model JMW, Daikin, Bryant, Florida Heat Pump, Climate Master, McQuay, Geoexcel, Geocomfort, or approved equal.

B. General:

1. Equipment shall be completely assembled, piped, internally wired, and test operated at the factory. National Pipe Threaded (NPT) female domestic water inlet and outlet connections, NPT female condensate connection, thermostat field interface terminal strip, and all safety controls shall be furnished and factory installed. The system water inlet and outlet connections shall be a female NPT swivel quick connector with stainless steel stop ring that allows simplified field installation.
2. Equipment shall be ETL and CSA listed, and ARI 330 certified.
3. All equipment shall have decals and labels to aid in the service and indicate caution areas.

C. Casing:

1. The cabinet shall be constructed of galvanized heavy-gauge steel with an electrostatic powder paint finish for an appliance grade finish. The top, front half of the diagonal cabinet shall be removable for access to all of the internal components. All panels shall be insulated with ¾ inch thick, 1 ½ lb. density,

neoprene backed, acoustical fiberglass insulation.

D. Refrigeration System:

1. All refrigerant piping and heat exchangers shall be factory insulated to minimize heat transfer and eliminate condensation.
2. Compressor:

    a. The unit shall include a high efficiency, scroll compressor with internal vibration isolation that absorbs starting and stopping energy. External vibration isolation shall be provided by rubber mounting devices located underneath the mounting base of the compressor.
    b. Internal thermal overload protection shall be provided. Protection shall be provided against excessive discharge pressure operation by means of a high pressure switch. Loss of charge protection shall be provided by a low pressure switch.
    c. Where scheduled provide multistage units.
    d. All piping shall be factory insulated with insulation and vapor barrier to minimize heat transfer and prevent condensation.
    e. Furnish and install sound attenuation blankets on all compressors.
    f. Furnish units with provisions for head pressure control of modulating control valve furnished under Division 23 Section "Instrumentation and Controls of HVAC and Plumbing Systems".

3. Water-to-Refrigerant Heat Exchanger

    a. The water-to-refrigerant heat exchanger shall be a high quality, stainless steel, brazed plate heat exchanger, or cupro nickel.
    b. The coil shall have a working pressure rating of 450 psig on both the refrigerant and water sides. The coil shall have a bi-directional liquid line filter drier to remove any contaminants from entering the circuit.
    c. The heat exchanger shall be fully factory insulated with insulation and vapor barrier to prevent condensation.

4. Freezestat and Lock Out Relay:

    a. A freezestat shall be included to protect the unit from unusually cold fluid flow or no fluid flow conditions. A 20 degrees F freezestat shall be utilized for use on closed loop systems with antifreeze solution. All other types of systems typically shall use a 35 degrees F freezestat.
    b. A lockout relay circuit consisting of three safety devices - low pressure, high pressure, and freezestat, shall trigger the lockout relay to shut off the compressor, the loop pumps, and the desuperheater pump (where specified) if a problem is detected. A lockout relay may be reset by cycling the power to the unit.

5. Reversing Valve: The reversing valve shall be a pilot operating sliding piston type with replaceable encapsulated magnetic coil. The reversing valve shall be energized in the cooling cycle.
6. Refrigerant Tubing: Refrigerant tubing shall be copper. All low temperature refrigerant lines shall be insulated with an elastomeric insulation that has a 3/8

inch thick wall with a flame spread rating of less than 25 and smoke density rating of less than 50, as tested in accordance with ASTM-85. The elastomeric insulation shall have a UL 94V-5 rating.

7. Refrigerant Metering: The equipment shall be provided with a (TXV) thermal expansion valve to allow operation from 25 degrees F to 120 degrees F entering fluid temperature.
8. Refrigerant type shall be R-32 or R-454B.
9. Furnish units with modulating head pressure control valve on the water to refrigerant heat exchanger.

E. Servicing: the equipment shall be provided with both high and low pressure schrader ports for servicing.

F. Electrical: A factory or field tested and installed control box shall contain all necessary devices to allow heating and cooling operation of the equipment to occur from a remote temperature sensor. These devices shall be as follows:

1. 24 VAC, Energy Limiting Class II, 50 VA breaker type transformer.
2. Compressor controller shall be a 24 VAC contactor.
3. Thermostat connections shall be a terminal strip having a minimum of four terminals located on the unit. This interface shall provide the means of connection between the thermostat and operating controls contained within the unit.
4. An electrically operated safety lockout relay shall be provided to prevent cycling of the compressor during adverse conditions of operation. This device may be reset either at a remote thermostat or by cycling power to the unit.
5. A high pressure switch shall be provided to protect the compressor against operation at refrigerant system pressures in excess of 395 psig.
6. The low water temperature switch shall be provided to protect the water-to-refrigerant heat exchangers from freezing. This device shall prevent compressor operation at a leaving water temperature below 35 degrees F.
7. A 20 degrees Fahrenheit temperature switch shall be applied for low temperature or geothermal applications, where an appropriate antifreeze solution is used. This device shall prevent compressor operation at leaving fluid temperatures below 20 degrees Fahrenheit.
8. A low pressure switch shall be provided to prevent compressor operation under low charge or catastrophic loss of charge situations. The low pressure switch shall be set to activate at refrigerant pressures of 35 psig when a 35 degrees Fahrenheit freezestat is used; 7 psig when a 20 degrees Fahrenheit is use.
9. Furnish units with night setback relay, anti short cycle relay, and random start relay.
10. Nameplate information shall be provided within each unit to help identify the unit's model number, operating ranges, voltage ranges, and electrical specifications.
11. The DDC terminal unit controller for each heat pump shall be furnished by the Automatic Temperature Control Contractor for factory installation by the water to water ground source heat pump manufacturer or field installation by the Automatic Temperature Control Contractorl.
12. The DDC terminal unit controller shall be shipped by the Automatic Temperature Control Contractor to the water to water ground source heat pump manufacturer for installation at the factory. At Contractor's option, the DDC terminal unit

controllers may be installed in the field.

13. The cost of factory or field mounting, wiring, and any factory testing and programming of the terminal unit controller shall be included by the water to water ground source heat pump manufacturer.
14. The Automatic Temperature Control Contractor shall coordinate with manufacturer to ensure the delivery of factory or field installed controls and proper installation according to the project schedule.

G. Warranty: The unit shall be warranted by the manufacturer against defects in material and factory workmanship for one year. The refrigerant circuit including motor-compressor, expansion device, all heat exchangers in contact with refrigerants, and reversing valve (less solenoid coil) are warranted for four additional years (parts only).

2.27. WATER TO AIR GROUND SOURCE HEAT PUMP ROOFTOP UNITS

A. Provide water-to-air ground source rooftop heat pumps of the size, capacity, efficiency, and electrical characteristics as indicated on the Contract Drawings. Units shall be Versatec 500 Rooftop Series as manufactured by WaterFurnace, Aaon, Trane, McQuay, Johnson Controls, Florida Heat Pump, Climate Master, or approved equal.

B. Units shall be ARI 330 certified for use as extended range heat pumps for geothermal closed loop applications.

C. Equipment shall be completely assembled, piped, internally wired and test operated at the factory. Units shall be both ETL and ISO-ARI 13256-1 listed and labeled prior to leaving the factory. Service and caution area labels shall be also be placed on the unit in their appropriate locations. Wiring internal to the unit shall be colored and numbered.

D. Each unit shall be specifically designed for outdoor rooftop installation.

E. The units shall be furnished complete with insulated casing, centrifugal fans, power relief air fan, economizer outside air damper, return air damper coils as scheduled, insulated drain pan, motor, adjustable drives and accessories as required.

F. Adequate space around all sides of the rooftop units shall be provided for proper service and maintenance.

G. Each unit shall be completely assembled on a rigid base for one piece shipping and rigging. Each unit shall be mounted on a roof curb provided by the same manufacturer.

H. A/C condensate drain for each unit shall be insulated stainless steel. Condensate drains shall terminate on roof.

I. Provide N.F.P.A 90-A approved flexible duct connections on supply and return duct connections at unit.

J. Cabinet:

1. Unit casing shall be constructed of zinc coated, heavy gauge, galvanized steel. All components shall be mounted in a weather-resistant steel cabinet with a painted exterior. Service panel shall contain lifting handles that require no more

than three (3) screws while providing a water and air tight seal.

2. The insulation shall be 1½" inch thick dual density bonded glass fiber. The exposed side shall be a high density erosion proof material suitable for use in airstream up to 4500 feet per minute (FPM). Insulation shall meet the Underwriters Laboratories Fire Hazard Classification:

   a. Flame Spread = 20
   b. Fuel Contributed = 15
   c. Smoke Developed = 0

3. Access for inspection and cleaning of the unit drain pan, coils and fan section shall be provide. The unit shall be installed for proper access. Procedures for proper access inspection and cleaning of the unit shall be included in the maintenance manual.
4. Furnish units with 1 inch thick, pleated, 30 percent efficient removable filters with filter frame.
5. Filter racks shall be gasketed and air tight to prevent leakage.

K. Sound Attenuation:

1. Sound attenuation shall be applied as a standard feature in the product design.
2. The sound reduction package shall include a compressor discharge muffler, vibration isolation to the compressor and water-to-refrigerant coil, unit base stiffeners, insulated metal compressor enclosure, and a second stage of vibration isolation to the compressor and water-to-refrigerant base pan.
3. The unit shall be tested and rated in accordance with ARI 260P.
4. Furnish and install sound attenuation blankets.

L. Refrigeration System

1. The unit shall include a high efficiency, direct drive hermetic reciprocating compressor. Units 25 ton and larger shall be direct drive, hermetic, scroll type with gear type oil pump. External vibration isolation shall be provided by rubber mounting devices located underneath the mounting base of the compressor. A second isolation of the refrigeration assembly shall be supported under the compressor mounting base. Where scheduled provide multistage units.
2. Compressor motors shall contain centrifugal oil pump and shall be suction gas-cooled. Compressors shall include crank case heater, internal temperature and current-sensitive motor overloads.
3. Internal thermal overload protection shall be provided. Protection shall be provided against excessive discharge pressure operation by means of a high pressure switch. Loss of charge protection shall be provided by a low pressure switch.
4. Heat Exchanger: The water-to-refrigerant heat exchanger shall be of a high quality coil in shell type for maximum heat transfer. The cupro-nickel coil or stainless steel shall be deeply fluted to enhance heat transfer and minimize fouling and scaling. The coil shall have a working pressure of 450 psig of both the refrigerant and water sides. The factory shall provide rubber isolation to the heat exchanging device to enhance sound attenuation.
5. Reversing Valve: The reversing valve shall be a pilot operating sliding piston type with replaceable encapsulated magnetic coil. This valve shall be energized

in cooling.

6. Tubing: The refrigerant tubing shall be of 99 percent pure copper. This system shall be free from contaminants and conditions such as drilling fragments, dirt and oil. All refrigerant and water lines shall be insulated with an elastomeric insulation that has a 3/8-inch thick wall wherever air is introduced to the assembly.
7. Refrigerant Metering: The equipment shall be provided with a (TXV) thermal expansion valve to allow operation of the unit with entering fluid temperature from 25 degrees Fahrenheit to 125 degrees Fahrenheit. Refrigerant circuits shall contain service pressure ports and factory installed refrigerant line filter dryer.
8. Schrader Connections: The refrigerant access ports shall be factory supplied on the high and low pressure sides for easy refrigerant pressure or temperature testing.
9. Refrigerant type shall be R-32 or R-454B.
10. All refrigerant piping and heat exchangers shall be factory insulated to minimize heat transfer and eliminate condensation.

M. Air-to-Refrigerant Coil:

1. The air-to-refrigerant coil shall contain copper tubes mechanically expanded into evenly spaced aluminum fins. All coils are to be leak tested. Pressure testing shall be performed at 450 psig operating pressure and the leak test at 125 psi operating pressure with helium. In addition, the tubes are to be completely evacuated of air prior to shipment.
2. The refrigerant coil distributor assembly shall be of orifice style with round copper distributor tubes. The tubes shall be sized consistently with the capacity of the coil. Suction headers shall be fabricated from rounded copper pipe.
3. A thermostatic expansion valve shall be factory selected and installed for a wide range of control.
4. Unit shall be factory furnished with hot gas re-heat coil with modulating hot gas re-heat valves.
5. Evaporator coil shall be interlaced type.
6. Water side of refrigerant coil shall include modulating head pressure control valve.
7. Furnish separate modulating hot gas reheat coil for active dehumidification.

N. Drain Pan

1. The condensate pan shall be constructed of high impact plastic to prevent corrosion and sweating. The bottom of the drain pan shall be sloped on two planes to provide complete drainage of water from the pan. The unit shall be supplied with a standard solid-state electronic condensate overlow protection. Water level detection shall comply with U.L. 508. Drain pan shall be insulated to prevent condensation.

2. Electrical

   a. The factory or field tested and installed control box shall contain all necessary devices to allow heating and cooling operation of the equipment to occur from a remote wall thermostat or zone sensor. Thermostats and zone sensors shall be furnished under Division 23

Section, Instrumentation and Controls of HVAC and Plumbing System. The devices shall be as follows:

i. 24 VAC Energy Limiting Class II, 50VA breaker type transformer (minimum)
ii. 24 VAC contactor for compressor control
iii. 18 Pole terminal strip located inside the control box behind the service access panel. This terminal strip shall be used for low voltage (thermostat/zone sensor) connections.
iv. An electrically operated safety lockout relay shall prevent cycling of the compressor during adverse conditions of operation. This device shall be reset either at the remote thermostat/zone sensor, or by cycling power to the unit.
v. A high pressure switch shall protect the compressor against operation at refrigerant system pressure in excess of 395 psig.
vi. A low pressure switch shall prevent compressor operation under low charge or catastrophic loss of charge situations.
vii. Factory installed wire harness.
viii. Factory installed and wired disconnect switch.

O. Controls

1. Terminal Unit Controller: This system shall utilize factory furnished and mounted DDC controls for operation of a complete building system on a Comm 4 link. The TUC control package shall include a 75 VAC transformer. The controller shall provide anti-short cycle compressor protection, random start, heating/cooling status, occupied/unoccupied mode, as well as fan and filter status options. Optional wiring from the factory for condensate overflow shall be provided. Five LEDs (light emitting diodes) shall also be included for diagnostics of the equipment.
2. BAS Communication Interface: There shall be a BAS Communication Interface that ties into the Unit Control Processor. This system shall provide the following diagnostic information: Communication Network Status at each unit, Mode of Operation, System Cooling and Heating Setpoints, Local Cooling and Heating Setpoints, Compressor Operational Status, Reversing Valve Status, Zone Temperature, Discharge Air Temperature, Leaving Water Temperature, Fan Mode, Fan Status, and Compressor Fault Status.
3. Controls: Factory or Field wired, control shall perform the following:

   a. Random start of all water source heat pumps.
   b. Anti-short cycle protection shall prevent rapid cycling of the compressor during changeover from heat to cooling or vice-a-versus.
   c. A two wire twisted pair shall be able to perform the following functions when connected to the control system: load shedding. Emergency shutdown. Time of day scheduling. Alarm shutdown as a result of: Loss of water flow. High water temperature. Low water temperature.
   d. Delays shall prevent the reversing valve from changing status against large differentials in pressures within the hermetically sealed system.
   e. A single common alarm output shall be provided to: Initiate an alarm at the EMS.
   f. The control system shall monitor the current to the compressor contactor

via a high pressure switch. If this switch activates and causes a loss of current to the contactor during a compressor "on mode", then the control system shall shutdown the water source heat pump and cause the common alarm output to be energized.

g. The controls shall monitor the low refrigerant pressure and if it activates during the compressor "on mode", then the controls shall shutdown the water source heat pump and cause the common alarm output to be energized.

h. A freeze protection thermostat shall sense leaving water temperature. If the water temperature falls below the set point, the controls shall shutdown the water source heat pump and cause the common alarm output to be energized.

i. The control system shall visually display the following alarm conditions via the BAS. High pressure, Low refrigerant temperature, Condensate overflow.

j. The control system shall require a manual reset to restore normal operation after any of the following alarm conditions: high pressure, low refrigerant temperature, or condensate overflow.

k. The control system shall visually display the status of the water source heat pump at all times. Definition of all possible status shall be indicated at the BAS.

l. The control system shall provide a field service input for diagnostic purposes.

m. Condensate overflow switch shall be provided to lock out the compressor operation when a high level of water is detected.

n. All water lines, refrigerant lines, hot gas lines and condensate lines shall be fully insulated with 1-inch closed cell insulation.

o. The DDC terminal unit controller for each heat pump shall be furnished by the Automatic Temperature Control Contractor for factory installation by the water to air ground source heat pump rooftop unit manufacturer or field installation by the Automatic Temperature Control Contractor.

4. The DDC terminal unit controller shall be shipped by the Automatic Temperature Control Contractor to the water to air ground source heat pump rooftop unit manufacturer for installation at the factory. At Contractor's option, the DDC terminal unit controller may be installed in the field.

5. The cost of factory or field mounting, wiring, and any factory testing and programming of the terminal unit controller shall be included by the water to air ground source heat pump rooftop unit manufacturer.

6. The Automatic Temperature Control Contractor shall coordinate with manufacturer to ensure the delivery of factory or field installed controls and proper installation according to the project schedule.

P. Economizer Control:

1. Units shall be factory furnished complete for full enthalpy economizer operation with power relief.

2. Furnish each unit with a factory installed differential electronic enthalpy automatic economizer to accomplish the following:

a. Furnish unit with outdoor and return air dampers that are interlocked and positioned by a fully-modulating, spring-return damper actuator. The maximum leakage rate for the outdoor air intake damper shall not exceed 2 percent when dampers are fully closed and operating against a pressure differential of .50 inches water gauge.

b. During economizer operation, a mixed-air temperature controller shall modulate the outdoor and return air damper assembly to prevent the mixed air temperature from dropping below 55 degrees F. Changeover from compressor to economizer operation shall be provided by an integral electronic enthalpy control that feeds input into the logic module. An additional electronic enthalpy sensors shall supply input to the logic module which modulates both sets of dampers for maximum economizer savings. Simultaneous economizer/compressor operation shall be possible for maximum economy.

c. The economizer intake opening shall be covered with a rain hood that matches the exterior of the unit. Water eliminator/filters shall be provided on all intakes.

d. Contractor shall provide and install a motorized relief air damper that is interlocked with a space differential pressure sensor to relieve air during economizer operation.

3. Housing: Piping and electrical shall enter unit concealed within insulated roof curb. All piping within the unit enclosure shall be insulated with insulation type and thickness as specified in Division 23 Section, HVAC Insulation.

Q. Motors: The motors shall be premium efficiency type with thermal overload protection. Where required, standard static or high static shall be selected and wired from the factory to match performance criteria.

R. Fans: The supply fan shall be placed in a draw-through configuration. The fan shall be constructed of corrosion resistant galvanized material. Fans shall be belt driven, forward covered, centrifugal type with adjustable motor sheeves. Relief air fan shall be a propeller type direct drive fan.

S. Accessories:

1. The following additional accessories/options shall be either factory installed or provided for field installation.

a. A 14 inch knockdown roof curb, provided by the same manufacturer, which shall provide a water-tight seal between the roof and the curb. Curbs shall be approved by the National Roofing Contractor Association.

b. A 5 minute timer to prevent the compressor from short-cycling.

c. A lockout circuit to prevent the compressor from cycling on one of the safety controls.

T. Source Quality Control.

1. Verification of Performance: Rate capacity according to ARI 210/240, "Unitary Air-conditioning and Air Source Heat Pump Equipment."

2. Verification of Performance: Rate capacity according to ARI 360, "Commercial and Industrial Unitary Air-Conditioning Equipment."

3. Sound Power Level Ratings: Comply with ARI 270, "Standard for Sound Rating of Outdoor Unitary Equipment."
4. Sound Power Level Ratings: Comply with AMCA Standard 300 to generate supply air borne and return air borne sound power ratings.

U. Warranty; The unit shall be warranted by the manufacturer against defects in material and factory workmanship for two (2) years. The refrigerant circuit including motor-compressor, expansion device, all heat exchangers in contact with refrigerants, and reversing valve (less solenoid coil) shall be warranted for four (4) additional years.

2.28. GEOTHERMAL SYSTEM AND DUAL TEMPERATURE SYSTEM FLUID FILTER HOUSING AND FILTERS

A. Furnish and install HARMSCO Model Bay SB or approved equal type swing bolt filter housing and filters in the geothermal system and dual temperature system as indicated on the contract drawings. Swing bolt housings shall be rated for 150 psig 275°F and shall be built to ASME design standards.

B. Filter housing shall include the following features:

1. Electro polish or matte finish.
2. Swing bolt closure system.
3. Combination cyclone separator and bag filter in a single compact design.
4. 304C stainless steel housing, standpipes, and internal components.
5. Inlet/Outlet flange connections.
6. 1-1/2 inch FNPT Drain.
7. ½ inch FNPT Lid Vent.

C. Furnish with #2 extended bags and a spare set of bag filters.

D. Provide polyester cartridge filters will full spare set. Filters shall be 5 micron type.

PART 3. EXECUTION

3.1. EXAMINATION

A. Verify all dimensions by field measurements. Verify that all equipment may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.

B. Verify structure, mounting supports and membrane installations are completed to the proper point to allow installation of roof mounted equipment, where applicable.

C. Examine rough-in requirements for all piping systems to verify actual locations of piping connections prior to installation.

D. Verify that electrical work installation is in accordance with manufacture's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until electrical work is acceptable to equipment installer. Coordinate sizes of all thermal overloads with Division 26.

E. Do not proceed until unsatisfactory conditions have been corrected.

F. Provide wiring diagrams of all equipment as specified in Division 23 Section, Common Work Results for HVAC.

3.2. GENERAL INSTALLATION REQUIREMENTS

A. Install all equipment in accordance with manufacturer's installation instructions, in accordance with state and local code requirements, and in accordance with the contract drawings. Install all equipment plumb and level, to tolerances as required by the manufacturer of each item of equipment. Maintain manufacturer recommended clearances around and over all equipment. Water heater minimum clearances shall be provided per the State of Delaware Requirements.

B. Coordinate vibration isolation requirements with all equipment in accordance with Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment.

C. Coordinate all electrical requirements with Division 26.

D. Coordinate all indoor and outdoor equipment pad locations and sizes with approved shop drawing submittals. Provide operating weights of equipment to Structural Engineer for review. Coordinate equipment pad locations and sizes with the Concrete Contractor or General Contractor. Furnish anchor bolts which are to be inserted in concrete pads to concrete installer.

E. Verify piping arrangements of all equipment with the contract drawings. Piping details shall be strictly adhered to concerning valves, fittings, components, etc. At coils, where a rebuildable and repairable autoflow valve is installed in the line without the need for draining or shutting of the water, the same may be utilized as the isolation valve and additional shut-off valve is not required.

F. Connect all equipment, devices and components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.

G. Testing: After installing HVAC equipment, devices and components and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

H. Remove and replace malfunctioning units with new units and retest.

I. All mechanical penetrations or terminations in exterior walls shall be flashed and caulked watertight. Furnish and installed lintels as required.

J. Arrange for equipment such as air handling units, energy recovery units, heat pumps, rooftop water source heat pumps, and kitchen make-up air units to be shipped to project in modules where space constraints require the same. Field erect components as required.

3.3. FIELD QUALITY CONTROL

A. Where indicated provide the services of a factory authorized service representative to examine the field assembly of components, installation, piping, electrical connections, controls, and clearances. Submit factory start-up check list to Engineer for information purposes. Testing and balancing work shall not commence until start-up reports have been completed, reviewed by Engineer, and forwarded to Testing and Balancing Agency.

B. Where factory start-up of equipment is not specified, provide field start-up by qualified technician to examine the field assembly of components, installation, piping, electrical connections, controls and clearances. Record equipment manufacturers standard start-up information and submit to Engineer for review. Testing and balancing work shall not commence until start-up reports have been completed, reviewed by Engineer, and forwarded to Testing and Balancing Agency.

C. Charge all refrigerant systems with refrigerant and oil and test for leaks. Repair leaks and replace lost refrigerant and oil.

D. Fill all hydronic systems with water and/or antifreeze (when required after flushing and test for leaks. Repair leaks and replace lost water and/or antifreeze. Coordinate with water treatment contractor.

E. Submit to Engineer a written table of all relief valve and make-up water valve settings for each system. Provide an additional copy in the Operations and Maintenance Manuals.

F. Verify proper motor sizes, voltages, thermal overloads, nameplate data, etc. All equipment voltages and current shall be recorded to insure that motors are operating below their service factors. Test and Balance Engineer shall record electrical data before continuous or permanent operation.

3.4. DEMONSTRATION

A. Provide the services of a factory authorized service representative to provide start-up and to demonstrate and train the Owner's maintenance personnel.

B. Place equipment into operation and adjust controls and safeties. Replace damaged or malfunctioning components and controls.

C. Training:

1. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, lubrication, servicing procedures and preventative maintenance schedules/procedures. Review with the Owner's personnel, the contents of the operation and maintenance data specified in Division 23 Section, Common Work Results for HVAC.
2. Submit operation and maintenance data as soon as possible prior to project close-out. Operations and maintenance data shall be submitted to the Owner for review and comment prior to submission to the Engineer.
3. Schedule training with the Owner through the Architect and/or Engineer with at

least seven (7) days prior notice.

D. Contractor shall demonstrate removal and replacement of filters at all pieces of equipment with filters in the prescence of the Owners representative.

3.5. CLEANING

A. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

B. Clean fan and equipment interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering air face.

3.6. AIR HANDLING UNIT INSTALLATION REQUIREMENTS

A. Install in conformance with ARI 435. Install air handling units level and plumb, according to manufacturer's written instructions.

B. Install AHU's with resilient mounting and flexible electrical leads.

C. Install flexible connections as hereinafter specified at all duct connections.

D. Comb out fins on AHU coils where deformed or bent. Replace or repair broken fins.

E. Install coils level. Install cleanable tube coils with 1:50 pitch.

F. Make connections to coils with unions and flanges.

G. Provide air tight seals between coils and duct or casings. Gasket all access panels, door openings and inspection windows. Seal all joints between sections.

H. Insulate all headers outside air flow as specified for piping.

I. Arrange installation of units to provide access space around air handling units for service and maintenance.

J. Adjust damper linkages for proper damper operation.

K. Install air tight seals at all air handling penetration points, including pipe penetrations at the coils, unused maintenance - only drain openings, and any penetrations for electrical wiring.

3.7. DUCTLESS UNITS EQUIPMENT INSTALLATION REQUIREMENTS

A. Mount indoor and outdoor units as detailed on contract drawings.

B. Supply initial charge of refrigerant and oil as required.

C. Install all interlock and control wiring between indoor units, outdoor units thermostats, and condensate pumps.

D. Install outdoor units on roof curbs as indicated on drawings.

E. Comb out fins on condensing unit where deformed or bent. Replace or repair broken fins.

F. Install condensate lift pumps, float switches, alarm, unit shut down wiring and detection block units per manufacturer's recommendations.

G. For wall mounted units, locate condensate pumps above ceiling. Install all piping, tubing between indoor unit, adapter, detection block, and condensate pump.

H. For wall mounted units field wire power wiring, alarm circuits, control cable, safety circuit connection, alarm, and condensate pump. Condensate pump shall be powered from indoor unit power wiring. Coordinate condensate pump electrical characteristics with indoor unit electrical characteristics.

I. Install wind baffles when required for low ambient operation. Locate wind baffles facing the predominant wind direction in winter.

3.8. ELECTRIC HEATING EQUIPMENT INSTALLATION REQUIREMENTS

A. Examine heating units for compliance with requirements for installation tolerances and other conditions affecting performance of units. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Connect heating units and components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.

C. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris; repair damaged finishes, including chips, scratches, and abrasions.

D. Install and mount electric radiant heat panels from building structure as required to accommodate ceiling type. Field furnish all accessories necessary to mount radiant heat panels.

3.9. FAN INSTALLATION REQUIREMENTS.

A. Install fans with resilient mounting and flexible electrical leads.

B. Install flexible connections and vibration isolators as specified in Division 23 Section, Common Work Results for HVAC and Division 23 Section Vibration Controls for HVAC, Plumbing and Fire Protection Equipment. Ensure metal band of connectors are parallel with minimum one inch flex between ductwork and fan while running.

C. Provide safety screens/guards on all fans and permanently mount after final testing and balancing.

D. For UL 762 Kitchen Hood exhaust fans the wiring shall be routed outside of airstream through the breather tube.

E. Do not operate fans for any purpose until ductwork is clean, filters in place, bearings lubricated, and fans have been test run under operation.

F. Provide sheave required for final air balance.

G. Install fans according to manufacturer's written instructions.

H. Adjust damper linkages for proper damper operation.

I. Adjust belt tension.

J. Lubricate bearings.

K. Replace fan and motor pulleys and belts as required to achieve design conditions.

L. Mount, install, and wire speed controllers for direct drive fans. Speed controllers for direct drive fans shall be mounted adjacent to fan and wired in accordance with the NEC.

3.10. HVAC PUMP INSTALLATION REQUIREMENTS

A. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.

B. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For close coupled or base mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 inches (102 mm) and over.

C. Provide drains for bases and seals, piped to and discharging into floor drains.

D. Check, align, and certify alignment of base mounted pumps prior to start-up. Prior to starting pumps, the alignment of the pumps and their motors or other drivers shall be carefully checked. Alignment should be checked for both offset and angularity. Alignment by means of a Laser for all pumps. Alignment by straight edge across the pump couplings shall not be acceptable. Submit laser pump shaft alignment results to Engineer for review and insert a copy in the Operation and Maintenance Manuals.

E. Install close coupled and base mounted pumps on concrete housekeeping pads, with anchor bolts, set and level, and grout in place. See Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment for inertia pad requirements. After alignment is correct, tighten foundation bolts evenly but not too firmly, completely fill baseplate with non shrink, non metallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

F. Lubricate pumps before start-up.

G. Provide side-stream filtration system for base mounted pumps. Install across pump with flow from pump discharge to pump suction from pump tappings. Install flow indicator, filter housing with cartridge filter, shut-off valves, and flow control valves. Install 30 micron filter for start-up and 5 micron filter for system operation.

H. Install pumps according to manufacturer's written instructions.

1. Install pumps according to HI 1.1 1.5, Centrifugal Pumps for Nomenclature, Definitions, Application and Operation.

I. Install pumps to provide access for periodic maintenance, including removing motors, impellers, couplings, and accessories.

J. Suspend in line pumps using continuous thread hanger rod and vibration isolation hangers. Install kindorf pump supports for vertical in-line pumps and maintain clear space above for future motor replacement.

K. 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 baseplate 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 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.

3.11. HYDRONIC EQUIPMENT AND SPECIALTIES INSTALLATION REQUIREMENTS

A. Where large air quantities can accumulate, provide enlarged air collection standpipes.

B. Provide manual air vents at system high points and as indicated.

C. For automatic air vents provide vent tubing to nearest drain.

D. Provide air separator on suction side of system circulation pump and connect to expansion tank.

E. Provide valved drain and hose connection on strainer blow down connection.

F. Provide pump suction fitting on suction side of base mounted centrifugal pumps. Remove temporary strainers after cleaning systems.

G. Support pump fittings with floor mounted pipe and flange supports.

H. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment and in accordance with ASME requirements.

I. Pipe all relief valve outlets to nearest floor drain.

J. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

K. Perform test determining strength of antifreeze and water solution and submit written test results. At Project completion close the make-up water valve train and open the glycol feeder valve train and turn on glycol feeder to prevent dilution of the antifreeze concentration in the system.

L. Install equipment exposed to finished area after walls and ceiling are finished and painted. Avoid damage.

M. Protection: Provide finished cabinet units with protective covers during balance of construction.

N. Testing: After installing and connecting units, demonstrate product capability and compliance with requirements.

O. Remove and replace malfunctioning units with new units and retest.

P. Furnish and install ball valves at all air separator high capacity air vents.

3.12. INCREMENTAL EQUIPMENT INSTALLATION REQUIREMENTS

A. Coordinate installation of all incremental units with architectural and electrical work.

B. Install as indicated. Coordinate to assure correct recess size for recessed units.

C. Units with Cooling Coils: connect drain pan to condensate drain

D. Coordinate cover openings for all thru-the-wall units with architectural work. Coordinate installation of wall sleeves in finished wall assembly; seal and weather proof.

E. Vacuum out all units and replace filters prior to turning over the same to the owner.

F. Electrical: Connect units to wiring systems and to ground as indicated and instructed by manufacturer.

G. Ground equipment

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

H. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

I. Lubricate bearings on fan.

J. Check fan-wheel rotation for correct direction without vibration and binding.

K. Start unit according to manufacturer's written instructions.

1. Complete manufacturer's startup checks.

L. After starting and performance test, change filters.

3.13. KITCHEN VENTILATION EQUIPMENT INSTALLATION REQUIREMENTS

A. Install all kitchen ventilation equipment in accordance with NFPA-96, NFPA-90A, NFPA-90B, and the requirements of the local Health Department.

B. Install gas fired units in accordance with NFPA-54 where applicable .

C. Provide flexible duct connectors on outlet from makeup air unit.

D. Rooftop units shall be installed on curbs and shall be leveled.

E. Indoor units shall be installed on housekeeping pads and shall be leveled.

F. The installer of the kitchen hood equipment shall submit a certification of installation to the Delaware Office of State Fire Marshal.

G. Provide factory start-up and training. Submit start-up reports to Engineer.

H. Interlock air flow monitoring station with ATC system.

I. Interlock make-up air unit with kitchen hood exhaust fan hood suppression system and gas solenoid valve.

J. Verify and record minimum and maximum air flow rates for the supply and exhaust air fan.

K. Verify and record the minimum and maximum supply/exhaust fan speeds/ hertz and incorporate into the fan tracking sequence of operation.

L. Verify and record temperature rise across all heating coils or furnaces.

M. Verify and record dry bulb and wet bulb temperatures across all cooling coils.

N. For gas fired equipment verify and record gas pressure at burner manifold.

O. Test all freeze protection pumps.

3.14. ROOFTOP UNITS INSTALLATION REQUIREMENTS

A. Verify that roof is ready to receive work and opening dimensions are as required.

B. Mount unit on factory built roof mounting curb providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.

C. Coordinate installation of roof curbs, equipment supports and roof penetrations with roof construction. Service platform shall bolt to curb per manufacturer’s requirements with stainless steel hardware.

D. Examine roof for compliance with requirements for conditions affecting installation and performance of rooftop units. Do not proceed with installation until unsatisfactory conditions have been corrected.

E. Install units according to manufacturer's written instructions.

F. Install units level and plumb, maintaining manufacturer's recommended clearances.

G. Curb Support: Install roof curb on roof structure, level, according to NRCA's written installation instructions. Install and secure rooftop units on curbs and coordinate roof penetrations and flashing with roof construction. Where service platform is indicated bolt to curb per manufacturers requirements with stainless steel hardware.

H. Unit Support: Install unit on structural curbs and level. Coordinate wall penetrations and flashing with wall construction.

I. Provide factory start-up and training. Submit start-up reports to Engineer.

J. Examine areas to receive units for compliance with requirements for installation tolerances and other conditions affecting performance of energy recovery units. Do not proceed with installation until unsatisfactory conditions have been corrected.

K. Install CO2 sensor/control/interlock wiring to variable frequency drives and to ATC system. Install global CO2 sensor to monitor ambient outside air CO2 level.

L. Install and interlock space CO2 sensors.

M. Install heat wheels so supply and exhaust flow in opposite directions and rotation is from exhaust side to purge section to supply side.

1. Provide access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.
2. Provide removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.

N. Install and interlock outside air flow monitoring station.

O. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

P. Ducts and fan installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

Q. Ground Equipment

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

R. After completing system installation, including outlet fittings and devices, inspect and clean exposed finishes. Remove dirt and construction debris and repair damaged finishes.

S. Startup Services: Engage a factory-authorized service representative to commission units as specified below.

1. Energize and verify correct rotation of heat wheels and fans.
2. Adjust seals and purge.
3. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
4. Test refrigerant circuit and controls.
5. Record refrigerant pressures.
6. Verify sequence of operation.
7. Test economizer and relief air damper operation.
8. Test dehumidification system and hot gas re-heat coil operation.
9. Test freeze protection pumps and all interlock wiring/controls.
10. Test and interlock duct smoke detectors.
11. Test differential static pressure sensor and its interlock with the relief air damper.

T. Training

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventative maintenance.
2. Review data in the operation and maintenance manuals. Refer to Division 01 Section, Demonstration and Training.
3. Schedule training with Owner, through Architect, with at least 7 days advance notice.

3.15. WATER TREATMENT INSTALLATION REQUIREMENTS

A. Systems shall be operational, filled, started, flushed, and vented prior to cleaning. Use water meter to record capacity in each system. All strainers shall be pulled and cleaned.

B. Place terminal control valves in open position during cleaning. Open bypass valves on coils and close isolation valves on coils during initial flushing.

C. Verify that electric power is available and of the correct characteristics.

D. Use neutralizer agents on recommendation of system cleaner supplier and approval of Architect.

E. Flush open systems and closed systems with clean water for four (4) hours minimum. Drain completely and refill. Where indicated add antifreeze.

F. Remove, clean, and replace strainer screens.

G. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

H. Test and submit antifreeze concentration where the same is utilized and submit concentration at substantial completion.

3.16. ENERGY RECOVERY VENTILATOR INSTALLATION REQUIREMENTS

A. Examine areas to receive energy recovery units for compliance with requirements for installation tolerances and other conditions affecting performance of energy recovery units. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Install energy recovery units as indicated, according to manufacturer's written instructions.

C. Install CO2 sensor/control/interlock wiring to variable frequency drives and to ATC system. Install global CO2 sensor to monitor ambient outside air CO2 level.

D. Install and interlock space CO2 sensors.

E. Install heat wheels so supply and exhaust flow in opposite directions and rotation is from exhaust side to purge section to supply side.

1. Provide access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.
2. Provide removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.

F. Install and interlock air flow monitoring stations as indicated on the contract drawings.

G. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

H. Ducts and fan installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

I. Ground Equipment

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

J. After completing system installation, including outlet fittings and devices, inspect and clean exposed finishes. Remove dirt and construction debris and repair damaged finishes.

K. Startup Services: Engage a factory-authorized service representative to commission units as specified below.

1. Energize and verify correct rotation of heat wheels and fans.
2. Adjust seals and purge.
3. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
4. Verify sequence of operation.
5. Record fluid temperatures, pressure drops, and flow rates.
6. Verify and record minimum and maximum air flow rates for the supply and

exhaust air fan.

7. Verify and record the minimum and maximum supply/exhaust fan speeds/ hertz and incorporate into the fan tracking sequence of operation.
8. Test A/C condensate overflow safety switch.
9. Verify and record the minimum and maximum supply/exhaust fan speeds/hertz and incorporate into the fan tracking sequence of operation.
10. Test freeze protection pumps.

L. Training

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventative maintenance.
2. Review data in the operation and maintenance manuals. Refer to Division 01 Section, Demonstration and Training.
3. Schedule training with Owner, through Architect, with at least 7 days advance notice.

3.17. WATER SOURCE HEAT PUMP EQUIPMENT INSTALLATION REQUIREMENTS

A. Examine areas and conditions for compliance with requirements for installation tolerances, other specific conditions, and other conditions affecting performance of water-source heat pumps. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Examine piping and electric rough installations for water-source heat pumps to verify actual locations of piping connections before installation.

C. Install water-source heat pumps according to manufacturer's written instructions.

D. Install units level and plumb, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances. Install water-to-water heat pumps on vibration isolation pads and concrete housekeeping pads.

E. Piping Connections: Drawings indicate the general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Connect supply and return piping to heat pump with unions and shutoff valves.
2. Connect refrigerant piping to fan coil units and heat pumps. Size and install refrigerant piping per heat pump unit manufacturer.
3. Connect heat-pump drain pan to nearest indirect waste connection, or air conditioning condensate pump or as indicated.
4. For large vertical console units, install pipe in pipe passage to allow left hand or right hand pipe entry as indicated.

F. Duct Connections: Connect supply and return ducts to heat pumps with flexible duct connections. Provide transitions to match unit duct-connection size. Completely seal and insulate where ductwork connects to unit and filter rack.

G. Connect low voltage float switch wiring to heat pumps where A/C condensate float switches are indicated.

H. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

I. Connect low voltage safety switch wiring to heat pumps where air conditioning condensate pumps are indicated.

J. Ground equipment.

1. 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.

K. Replace filters used during construction. Seal all return air ducts to filter racks. Seal air tight all filter racks.

L. Manufacturer's Field Service: Provide services of a factory-authorized service representative to supervise the field assembly of components and installation of water-source heat pumps, including piping and electrical connections. Report results in writing.

1. Test and adjust controls and safeties.
2. Replace damaged and malfunctioning controls and equipment.
3. Test and record refrigerant pressures, air flow rates, water flow rates, electrical characteristics. Start-up company and Test and Balance Engineer must both be present during start-up to simultaneously record the above data.
4. Test flow switches.
5. Where applicable, test dehumidification mode and hot gas re-heat valve operation.
6. Where applicable, test economizer operation and power relief air fan operation.
7. Where applicable test head pressure control valve.

M. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
2. Review data in the maintenance manuals specified in Division 01.
3. Schedule training with Owner, through Architect, with at least 7 days' advance notice.

N. Maintain minimum of 24 inches clear space at heat pump filter access. Provide manufacturer required clearances for service at ATC control panel, fan section, compressor section and electrical section. Maintain sufficient clear space below units to allow lowering and raising of units in the future.

O. All water source heat pumps shall be provided with auto-restart in the event of a power outage. Units shall automatically be enabled to re-start when power is restored.

P. For units with head pressure control coordinate head pressure control valve requirements and interlock requirements with the ATC subcontractor and BMS.

3.18. DUAL TEMPERATURE SYSTEM HYDRAULIC SEPARATOR TANK INSTALLATION REQUIREMENTS

A. Install tank level and plumb on concrete pad.

B. Arrange piping for easy tank replacement.

C. Install automatic air vent and pipe discharge to a floor drain.

D. Field insulate and jacket tank as specified.

E. Install flange and/or union connections at all taps, openings and fittings.

F. Install drain valve consisting of a tee fitting and ¾ inch ball valved piped to a floor drain.

G. Where required fill tank with glycol or treated water after flushing with fresh water.

H. Install 3-valve bypass arrangement as detailed on the Contract Drawings.

I. Install relief valve and pipe discharge with union to a floor drain.

3.19. DRYER DUCT BOOSTER FAN INSTALLATION REQUIREMENTS

A. Install transitions to dryer duct booster fans per details.

B. Furnish and install power and control wiring.

C. Install static pressure probe, tubing and pressure transducer. Set static pressure setpoint per the manufacturer’s requirements.

D. Test and operate all safeties.

E. Provide factory startup and training.

3.20. GEOTHERMAL AND DUAL TEMPERATURE SYSTEM FLUID FILTER HOUSING AND FILTER INSTALLATION REQUIREMENTS

A. Install filter housing and filters per the manufacturer’s requirements.

B. Install filter housing level and plumb on a concrete pad.

C. Arrange piping for easy filter housing replacement and to accommodate swing of the swing bolt closure system.

D. Install automatic air vent and pipe to discharge to a floor drain.

E. Filed insulate and jacket the filter housing.

F. Install flange and/or union connections at all taps, openings, and drain connections.

G. Install drain valve consisting of a tee fitting and 1-1/2 inch ball valve piped to a floor drain.

H. Install filters.

I. Install 3-valve bypass arrangement as detailed on the contract drawings.

J. Install relief valve and pipe discharge with union to a floor drain.

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DIVISION 23 SECTION 23 07 01
HVAC INSULATION
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SECTION 23 07 01 – HVAC INSULATION

PART 1. GENERAL

1.1. REFERENCE

A. The Conditions of the Contract and other General Requirements apply to the work specified in this Section. All work under this Section shall be subject to the requirements of Division 23 Section, Common Work Results for HVAC.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section

1.2. DESCRIPTION

A. All piping, ductwork, and equipment installed under this Contract shall be covered as specified.

1.3. SCOPE

A. The work covered by this specification consists of furnishing all labor, equipment, materials and accessories, and performing all operations required, for the correct fabrication and installation of thermal insulation applied to all piping, equipment, and duct systems, in accordance with applicable project specifications and drawings, subject to the terms and conditions of the contract.

1.4. STANDARDS

A. Thermal insulation materials shall meet the property requirements of one or more of the following specifications as applicable to the specific product or use:

1. American Society for Testing of Materials Specifications:

a. ASTM C 547, "Standard Specification for Mineral Fiber Preformed Pipe Insulation".
b. ASTM C 533, "Standard Specification for Calcium Silicate Pipe & Block Insulation".
c. ASTM C 55, "Standard Specification for Mineral Fiber Blanket and Felt Insulation".
d. ASTM E 96, "Standard Test Methods for Water Vapor Transmission of Material".
e. ASTM C 585, "Recommended Practice for Inner and Outer Diameters of Rigid Pipe Insulation for Nominal Sizes of Pipe and Tubing (NPS System)".
f. ASTM C 612, "Standard Specification for Mineral Fiber Block and Board Thermal Insulation".
g. ASTM C 1136, "Standard Specification for Barrier Material, Vapor, "Type 1 or 2 (Jacket only).

2. ASHRAE 90.1 "Energy efficient design of new buildings except low-rise residential buildings", latest edition.

3. International Energy Conservation Code, latest edition.

B. Insulation materials, including all weather and vapor barrier materials, closures, hangers, supports, fitting covers, and other accessories, shall be furnished and installed in strict accordance with project drawings, plans, and specifications.

1.5. SYSTEM PERFORMANCE

A. Insulation materials furnished and installed hereunder should meet the minimum economic insulation thickness requirements of the North American Insulation Manufacturers' Association (NAIMA) (formerly known as TIMA), to ensure cost-effective energy conservation performance. Alternatively, materials should meet the minimum thickness requirements of National Voluntary Consensus Standard 90.1, (latest edition) and "Energy Efficient Design of New Buildings," of the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), latest edition. However, if other factors such as condensation control or personnel protection are to be considered, the selection of the thickness of insulation should satisfy the controlling factor. As minimum, all insulation thicknesses shall be as hereinafter specified.

B. Insulation materials furnished and installed hereunder shall meet the fire hazard requirements of any one of the following specifications:

1. American Society for Testing of Materials ASTM E 84
2. Underwriters' Laboratories, Inc. UL 723
3. National Fire Protection Association NFPA 255
4. ASTM E 96, "Standard Test Methods for Water Vapor Transmission of Materials".

C. Calcium silicate products shall include a visual identification system to permit positive field determination of their asbestos-free characteristics.

1.6. QUALITY ASSURANCE

A. Insulation materials and accessories furnished and installed hereunder shall, where required, be accompanied by manufacturers' current submittal or data sheets showing compliance with applicable specifications listed in Section 1.4 above.

B. Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in commercial insulation work.

1.7. DELIVERY AND STORAGE OF MATERIALS

A. All of the insulation materials and accessories covered by this specification shall be delivered to the job site and stored in a safe, dry place with appropriate labels and/or other product identification.

B. The Contractor shall use whatever means are necessary to protect the insulation materials and accessories before, during, and after installation. No insulation material shall be installed that has become damaged in any way. The Contractor shall also use all means necessary to protect work and materials installed by other trades.

C. If any insulation material has become wet because of transit or job site exposure to moisture or water, the Contractor shall not install such material, and shall remove it from the job site. An exception may be allowed in cases where the Contractor is able to demonstrate that wet insulation when fully dried out (either before installation, or afterward following exposure to system operating temperatures) will provide installed performance that is equivalent in all respects to new, completely dry insulation. In such cases, consult the insulation manufacturer in writing for technical assistance.

D. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements. Protect all insulation from water, construction traffic, dirt, chemical and mechanical damage.

1.8. ALTERNATES

A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. GENERAL

A. All materials to be insulated shall be thoroughly cleaned, after completion of successful tests, and shall be covered as specified below. Fiberglass insulation shall be Owens-Corning, Manville, Armstrong, or P.P.G, or as approved equal.

2.2. PIPE INSULATION MATERIALS

A. Unless otherwise noted, insulation shall be one piece or half sectional molded fibrous glass with "K" rating of .23 at 75 degrees Fahrenheit mean temperature, for service temperatures between -60 degrees Fahrenheit and +450 degrees Fahrenheit with all service poly-encapsulated jacket. Pipe insulation shall be fiberglass ASJMax SSL II with double closure system as manufactured by Owens Corning, Johns Manville, Knauf or approved equal.

B. Exterior refrigerant pipe insulation shall be Armacell, or approved equal, foam insulation with exterior field applied aluminum jacketing. Interior refrigerant piping shall be Armacell or approved equal foam insulation. Where interior refrigerant piping is exposed also install field applied PVC jacketing.

C. Unless otherwise noted, pipe insulation jacket shall be factory-applied vinyl coated, embossed and reinforced vapor barrier laminate, with a perm rating of not more than 0.02 perms. All hot and cold, concealed and exposed butt strips shall be of the same material as the jacket. Jacket and butt strips shall be sealed with field-applied Foster 85-20/85-60 or Childers CP-82 (5 gal cans only) adhesive. Jacket and butt strips shall be off-white color and shall be equivalent to Owens-Corning Fiberglass 25-ASJ.

D. Indoor pipe insulation shall be ASJ Max with SSL-II closure system pipe insulation as manufactured by Owens Corning or approved equal. Pipe insulation shall be composed of heavy density fiberglass insulation with an organic binder. The insulation shall include a white, factory jacketed, resilient, tough, soil resistant polymer facing that matches standard PVD fitting covers. Furnish all accessories and matching butt joints sealing tape for system closure. Insulation shall be suitable for operating temperatures between 32 degrees Fahrenheit and 220 degrees Fahrenheit. Flame spread rating of 25 or less, and smoke development rating of 50 or less to comply with building codes for installation in return air plenums. The maximum thermal conductivity (K-value) at a mean temperature of 50 shall be .22 BTU-in/hr-Ft²-degress Fahrenheit.

E. For fittings on all piping, valves and flanges, apply fiberglass molded or segmented insulation equal in thickness to the adjoining insulation and securely fasten in place using wire. Cold piping: Apply a tack coat of vapor barrier coating and reinforcing mesh. After ½ hour, apply second coat of same vapor barrier coating, UL labeled, Type C, for cold water piping, Hot piping Type H for hot water piping: Apply tack of breather mastic. Wrap fitting with fiberglass reinforcing cloth overlapping adjoining sections of pipe insulation by 2-inches. Apply a second coat of breather mastic over the reinforcing cloth, working it to a smooth finish.

1. Vapor Barrier Coating: Foster 30-65; Childers CP-34 or Vimasco 749. Permeanie shall be 0.03 perms or less at 45 mils dry as test by ASTM E96.
2. Breather mastic: Foster 46-50; Childers CP-10/11 or Vimasco WC-5
3. Reinforcing Mesh: Foster Mast a Fab; Childers Chil Glas #10 or Vimasco Elastafab

F. All pipe insulation, jackets, or facings, and adhesives used to adhere jacket or facing to the insulation, including fittings and butt strips, shall have non-combustible fire and smoke hazard system rating and label as tested by ASTM E-84, NFPA 225, and UL 73, not exceeding Flame Spread 25, Fuel Contributed 50, Smoke Developed 50. Accessories such as adhesives, mastic cements, tapes and cloth for fittings shall have the same ratings as listed above. All products or their shipping cartons shall bear the Underwriter's label indicating that flame and smoke ratings do not exceed the above criteria.

G. For piping having a vapor barrier insulation and for all insulated piping requiring supports, hangers and supports shall be installed outside the insulation. Wherever hangers and supports are installed outside the insulation, pipe insulation protecting shields shall be provided. Where insulation is a load bearing material, of sufficient strength to support the weight of the piping, pipe shields one-third the circumference of the insulation and of a length not less than three times the diameter of the insulation (maximum length 24-inches) shall be provided. Insulation of 7-1/4 pound or greater density will be considered as load bearing for pipe sizes up to and including 2-inches. Where insulation is not of sufficient strength to support the weight of the piping, a half section of high density fiberglass or foam inserts, shall be provided. Vapor barrier and finish shall be applied as required to match adjoining insulation. In addition, shields shall be furnished as specified above.

H. For piping located outside of the building, a corrugated aluminum weatherproof jacketing system shall be provided. This system shall be Micro-Lot ML as manufactured by Manville, Polyweld by Pabco Metals Corp., Childers, or as approved equal, and installed per the manufacturer's recommendations. Where outdoor piping is receiving electric heat tape, the insulation shall be oversized so that the heat tape is not compressed tightly to the pipe. Pipe jacketing shall be corrugated (3/16-inch) deep aluminum, .016-inch thickness of H-14 temper with aluminum strapping of .75-inch width and .020 inch thickness with moisture barrier. Aluminum jacketing elbows shall be smooth, .016-inch thickness and 1100 alloy. All jacketing shall have an integrally bonded moisture barrier over the entire surface in contact with the insulation. Longitudinal joints shall be applied so they will shed water and shall be sealed completely with metal jacketing sealant. Sealant shall be Foster 95-44 or Childers CP-76. Circumferential joints shall be closed using preformed butt strips following manufacturer's recommendations for securement. Jacket seams shall be located on the bottom side of the horizontal piping. Where project has walk-in boxes provided by a Food Service Supplier, insulate and jacket all refrigerant piping serving walk-in coolers and freezers.

I. On cold systems such as refrigerant piping dual temperature piping, cooling coil drain piping, and geothermal heat pump piping, etc. vapor barrier performance is extremely important. All penetrations and seams of the ASJ and exposed ends of insulation must be sealed with vapor barrier coating. The ASJ must be protected with either a coating or a suitable vapor retarding outer jacket. Vapor seals at butt joints shall be applied at every fourth pipe section joint and at each fitting to provide isolation of water incursion. Vapor Barrier Coating: Foster 30-65; Childers CP-34 or Vimasco 749. Permeance shall be 0.03 perms or less at 45 mils dry as test by ASTM E96.

J. Fittings and valves shall be insulated with pre-formed fiberglass fittings, fabricated sections of fiberglass pipe insulation, Fiberglass pipe and tank insulation, Fiberglass blanket insulation, or insulating cement. Thickness shall be equal to adjacent pipe insulation. Finish shall be with pre-formed PVC fitting covers or as otherwise specified on contract drawings. Where applicable, Victaulic PVC fitting valve and coupling covers shall be utilized. Victaulic PVC covers shall be installed with matching pipe insulation jacketing material, vinyl tape solvent weld adhesive and appropriate fasteners.

1. Flanges, couplings and valve bonnets shall be covered with an oversized pipe insulation section sized to provide the same insulation thickness as on the main pipe section. An oversized insulation section shall be used to form a collar between the two insulation sections with low density blanket insulation being used to fill gaps. Jacketing shall match that used on straight pipe sections. Rough cut ends shall be coated with a suitable weather or vapor-resistant mastic as dictated by the system location and service. Finish valve installation with a Tyvac jacket with ends that secure to adjacent piping.
2. On hot systems where fittings are to be left exposed, insulation ends should be beveled away from bolts for easy access.
3. On cold systems, particular care must be given to vapor sealing the fitting cover or finish to the pipe insulation vapor barrier. All valve stems must be sealed with caulking which allows free movement of the stem but provides a seal against moisture incursion. All gauge and thermometer penetrations and extensions shall be correctly sealed and insulated to prevent surface condensation. Install oversized hangers to prevent penetrations of pipe insulation vapor barrier.

K. All piping shall be supported in such a manner that neither the insulation or the vapor/weather barrier is compromised by the hanger or the effects of the hanger. In all cases, hanger spacing must be such that the circumferential joint may be made outside the hanger. On cold systems, vapor barrier must be continuous, including material covered by the hanger saddle.

1. Piping systems 3-inches (7.5cm) in diameter or less, insulated with Fiberglass insulation, may be supported by placing saddles of the proper length and spacing, as designated in Owens-Corning Pub. 1-IN-12534, under the insulation. Hangers saddles shall be minimum 16 gauge with a saddle arc of 120 degrees minimum.
2. For hot or cold piping systems larger than 3-inches (7.5 cm) in diameter, operating at temperatures less than +200 degrees F (93 degrees C) and insulated with fiber

glass, high density inserts such as foam or wood blocks with sufficient compressive strength shall be used to support the weight of the piping system. At temperatures exceeding +_200 degrees F (93 degrees C), Owens-Corning Pink Calcium Silicate, IIG, or approved equal pipe insulation shall be used for high density inserts.

3. Owens-Corning Pink Calcium Silicate pipe insulation may be used to support the entire weight of the piping system provided the hanger saddle is designed so the maximum compressive load does not exceed 100 psi (7kg/cm).
4. Where pipe shoes and roller supports are required, insulation shall be inserted in the pipe shoe to minimize pipe heat loss. Where possible, the pipe shoe shall be sized to be flush with the outer pipe insulation diameter.
5. Thermal expansion and contraction of the piping and insulation system shall generally be taken care of by utilizing double layers of insulation and staggering both longitudinal and circumferential joints. Where long runs are encountered, expansion joints may be required where single layers of insulation are being used and should be so noted on the contract drawings.
6. On vertical runs, insulation support rings shall be used.

2.3. PIPING INSULATION THICKNESSES SCHEDULE

A. All piping shall be insulated with pipe insulation of the thicknesses indicted below:

PIPING INSULATION THICKNESS SCHEDULE SERVICES	THICKNESS
Automatic Glycol Feeder Piping	1 inch thickness
Interior Geothermal Piping, Including chemical treatment piping	1 ½ -inch thickness
Direct Buried Geothermal Exterior Piping	Refer to Div. 23 Section “Ground Loop Heat Pump Piping”
Horizontal portions of Stormwater piping that collects A/C condensate	1-inch thickness
All Drain Piping from Cooling Coils/Evaporators	1-inch thickness
Chemical Feed System	1-inch thickness
All Above Grade Floor Drain Piping Serving AHU Condensate Drains include Drain Sumps and Auxiliary Drain Pipes from Auxiliary Pans	1-inch thickness
All Refrigerant Piping	1-inch thickness
Dual Temperature Piping, including chemical treatment piping	2-inch thickness
Interior & Exterior Water Source Heat Pump Piping Including Chemical Treatment Piping	1-½ inch thickness
Kitchen Walk-in Box Refrigerant Pipes (Refer to Food Service Contract Drawings for location)	1-½ inch thickness

2.4. EQUIPMENT INSULATION MATERIALS AND THICKNESSES

A. The following equipment shall be insulated with Fiberglass Rigid Board Insulation or Foam Plastic Insulation:

1. Geothermal Pump Bodies.
2. Dual Temperature Pump Bodies.
3. Air Separators.
4. Expansion Tanks.
5. Chemical Feed Tanks.
6. Freeze Protection Pump Bodies.
7. All Pump Volutes and Strainers.
8. Geothermal System and Dual Temperature System Fluid Filter Housings.

B. Insulation for cold surfaces shall be 1-1/2-inch thickness, 6 lb. density, 705 FRK with a "K" rating of .23 at 75 degrees F mean temperature. Insulation for hot surfaces except as otherwise noted shall be 1-1/2-inch thickness, 6 lb. density, 705 with a "K" rating of .23 at 75 degrees F mean temperature. Insulation shall be applied with staggered joints firmly butted and joined. The insulation shall be held in place by steel bands. Bands shall be 1-inch by 25 gauge galvanized steel spaced on not over 12-inch centers. All joints and voids shall be filled with Owens-Corning #110 cement, well troweled into openings. For 705 FRK insulation, all joints and voids shall be FRK taped and vapor sealed. There shall be applied over the insulation surface 1-inch galvanized wire netting laced together at all edges and wired to the steel bands with 16 gauge soft annealed wire. Over this shall be applied 2-inch thick layer of Owens-Corning #110 cement applied in two layers. Install metal corner beads at all corners and edges in order to provide a permanent installation. Onto the dry cement surface apply a brush coat of Foster Sealfas 30-36 or Childers CP-50AMV1 lagging adhesive at the rate of 60-70 square feet per gallon. Cleanouts, nameplates, and manholes shall not be insulated, and the insulation on surrounding surfaces shall be neatly beveled off at such openings.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes from aluminum at least 0.040 inch (1.0 mm) thick.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

D. Boards shall be scored to allow them to conform to curved or irregular surfaces.

E. Mechanical fasteners shall be utilized to hold insulation to surface with bands as required to hold the curvature of the material.

F. Support rings shall be provided to support the top head insulation where required.

G. Outdoor installations require a weather barrier for protection of the insulation jacketing.

H. Insulation types materials shall be suitable for temperatures encountered by each item of equipment.

2.5. DUCTWORK INSULATION MATERIALS AND THICKNESSES

A. Insulate all supply, return, relief, combustion air, plenums, exhaust, (for ERV projects) and outside air intake ductwork with fiberglass exterior duct insulation with factory-applied foil facing. All exposed fiberglass duct insulation shall be 2-inch rigid or non-flexible board type 3.0 pcf minimum density, 0.23 max. "K" factor at 75 degrees F mean temperature, with white vinyl A.S.J. max, polymer coating vapor barrier facing. All concealed fiberglass duct insulation shall be 2-inch flexible blanket type, 1.0 pcf minimum density. All concealed insulation shall be 0.27 max. "K" factor at 75 degrees F mean temperature with reinforced foil-scrim Kraft vapor barrier facing. Unless otherwise noted, the minimum installed R-value shall be 6.0 HR x ft2 x ºF/btu.

B. Refer to Division 23 Section, HVAC Air Distribution System and contract drawings for location of all sound-lined ductwork. Sound-lined ductwork from the discharge or supply side of all air handling units, energy recovery units, heat pumps, make-up air units, and rooftop units shall require external insulation in addition to internal lining specified hereinafter. All other ducts indicated to be provided with interior lining shall not require additional exterior insulation.

C. Where exhaust ducts carrying moisture-laden air dishwasher exhaust, shower exhaust, etc. are routed in unconditioned spaces, insulation is required as described above. Insulation shall be continuous through the unconditioned area. The vapor barrier shall be tightly sealed to prevent condensation. Exhaust ducts located within conditioned spaces do not require insulation unless otherwise noted.

D. Where a vapor barrier is required, all joints, seams, tears, punctures, and other penetrations shall be closed with 3-inch (7.5cm) pressure-sensitive tape matching the facing or with vapor barrier coating reinforced with 3-inch (7.5cm) glass scrim tape.

E. Exposed dual wall ductwork located in finished areas shall not require additional exterior insulation. Exposed dual wall supply ductwork located in mechanical room, fan rooms, penthouse, mezzanines and boiler rooms shall require additional rigid exterior insulation as hereinafter specified.

F. Contractor-applied internal linings shall be as specified and installed as hereinafter specified.

G. For exposed Fiberglass duct insulation, tightly butt all edges and seams. Secure insulation with flush mechanical fasteners spaced not less than one per square foot. Insulation may be secured with 100 percent coverage of adhesive with mechanical fasteners on the underside of the duct only, in addition to adhesive. Adhesive shall be water based Foster 85-60 or Childers CP-127. Cover all seams, joints and fasteners with not less than 3-inch wide tape matching the insulation facing. Pre-finished white fastener caps may be left exposed if the spacing and pattern is uniform in appearance. Staples will not be permitted.

H. All supply air diffusers and supply air registers shall be fully insulated on the rear exposed surface to prevent condensation. Insulation shall be 1 ½" inch flexible blanket type 1 ½ pcf minimum density with reinforced foil-scrim-Kraft vapor barrier facing, .25 max "k" factor.

I. All airflow monitoring stations shall be externally insulated similar to adjacent ductwork as hereinbefore specified.

2.6. ACCESSORY MATERIALS

A. Accessory materials installed as part of insulation work under this section shall include, but not be limited to:

1. Closure Materials - Butt strips, bands, wires, staples, mastics, adhesives; pressure-sensitive tapes.
2. Field-applied jacketing materials - sheet metal, plastic, canvas, fiber glass cloth, insulating cement; PVC fitting covers, PVC jacketing.
3. Support Materials - Hanger straps, hanger rods, saddles.
4. Fasteners, weld pins/studs, speed clips, insulation washers.
5. Metal mesh or expanded metal lagging.

B. All accessory materials shall be installed in accordance with project drawings and specifications, manufacturer's instructions, and/or in conformance with the current edition of the Midwest Insulation Contractors Association (MICA) "Commercial & Industrial Insulation Standards."

2.7. GREASE DUCT ENCLOSURE WRAP

A. Provide listed grease duct enclosure wrap on all kitchen hood exhaust ducts. Duct wrap shall comply with ASTM E 2336-01 "Standard Test Method" for Fire Resistive Grease Duct Enclosure System. Duct wrap shall be Fire Master as manufactured by Thermal Ceramics, Fyerewrap as manufactured by Unifrax, and Fire Barrier as manufactured by 3M, Schebbler, or approved equal.

B. Duct wrap shall be foil-encapsulated, non-combustible, inorganic, flexible fire proofing wrap. Duct wrap shall be utilized in combination with Fire Master or approved equal, Putty and Fire Master or approved equal, bulk fiber to fire rate kitchen hood exhaust ducts. Duct wrap shall be capable of withstanding 2300 degrees F temperatures and protect combustible construction at zero clearance.

C. Two (2) layers of duct wrap shall be applied directly to the duct to provide a two (2) hour fire resistance enclosure for both vertical and horizontal duct runs. Apply putty and bulk fiber in conjunction with duct wrap at all duct penetrations of fire rated walls and ceilings. Insulate all duct access doors per U.L. listing and label per N.F.P.A.-96.

D. Furnish and install all material per manufacturer's installation requirements and per U.L. listing. Install support hangers, duct access door enclosures, and through penetration systems in accordance with NFPA-96, A.S.T.M. listing, and manufacturer's installation requirements.

E. Insulate all access doors and pitot tube openings. Install signs indicating either “access door” or “pitot tube”.

2.8. FIELD-APPLIED JACKET

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Johns Manville; Zeston.
   b. P.I.C. Plastics, Inc.; FG Series.
   c. Proto PVC Corporation; LoSmoke.
   d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: High gloss white.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

5. Factory-fabricated tank heads and tank side panels.

2.9. HANGER BLOCKS

A. For all pipes larger than 3 inches in diameter the hanger blocks shall be high compressive strength foam or wood blocks. Wood blocks shall be precision cut thickness to match specified insulation and shall include flared edge hanger saddle as manufactured by Buckaroo.

B. The wood blocks shall be suitable for temperatures from -120 degrees Fahrenheit to 200 degrees Fahrenheit. Do not utilize the wood blocks for piping systems operating outside of the indicated temperature range.

C. Wood blocks are not acceptable for use at refrigerant pipe hangers.

PART 3. EXECUTION

3.1. WORKMANSHIP

A. The Contractor shall take special care to prevent soiling equipment below or adjacent to areas being insulated. He shall be completely responsible for removing insulation cement splashes and smears and all surfaces that he mars or otherwise soils or defaces, and he will be totally responsible for restoring these damaged surfaces to their like-new condition when delivered to the site.

3.2. SITE INSPECTION

A. Before starting work under this section, carefully inspect the site and installed work of other trades and verify that such work is complete to the point where installation of materials and accessories under this section can begin.

B. Verify that all materials and accessories can be installed in accordance with project drawings and specifications and material manufacturers' recommendations.

C. Verify, by inspecting product labeling, submittal data, and/or certifications which may accompany the shipments, that all materials and accessories to be installed on the project comply with applicable specifications and standards and meet specified thermal and physical properties.

3.3. PREPARATION

A. Ensure that all pipe and equipment surfaces over which insulation is to be installed are clean and dry.

B. Ensure that insulation is clean, dry, and in good mechanical condition with all factory-applied vapor or weather barriers intact and undamaged. Wet, dirty, or damaged insulation shall not be acceptable for installation.

C. Ensure that pressure testing of piping or duct systems has been completed prior to installing insulation.

3.4. INSTALLATION

A. Piping Systems

1. General:

a. Install all insulation materials and accessories in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended purpose.
b. Install insulation on piping subsequent to installation of heat tracing, painting, testing, and acceptance tests.
c. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other. Butt insulation joints firmly to ensure complete, tight fit over all piping surfaces.
d. Maintain the integrity of factory-applied vapor barrier jacketing on all pipe insulation, protecting it against puncture, tear or other damage. Seal all tears, punctures and other penetrations of the pipe insulation vapor barrier coating.
e. On exposed piping, locate insulation and cover seams in least visible location.

2. Fittings: Cover valves, fittings, unions, flanges, strainers, flexible connections, expansion joints, pump bodies, drain valves, strainers, blowdowns, backflow preventers, autoflow valves and similar items in each piping system using one of the following:

a. Mitered sections of insulation equivalent in thickness and composition to that installed on straight pipe runs.
b. Cold pipe fittings: Apply a tack coat of vapor barrier coating and

reinforcing mesh to produce a smooth surface. After ½ hour, apply a second coat of same vapor barrier coating, UL labeled, Type C, for cold water piping.

c. Hot pipe fittings and Type H for hot water piping: Apply tack of breather mastic. Wrap fitting with fiberglass reinforcing cloth overlapping adjoining sections of pipe insulation by 2-inches. Apply a second coat of Type C or Type H breather mastic over the reinforcing cloth, working it to a smooth finish.

d. Insulation cement equal in thickness to the adjoining insulation.

e. PVC fitting covers insulated with material equal in thickness and composition to adjoining insulation.

3. Penetrations: Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise specified.

4. Joints:

a. Butt pipe insulation against hanger inserts. For hot pipes, apply 3-inch (7.5cm) wide vapor barrier tape or bank over butt joints. For cold piping, apply wet coat of vapor barrier lap cement on butt joints, and seal joints with 3-inch (7.5cm) wide vapor barrier tape or band.

b. All pipe insulation ends shall be tapered and sealed, regardless of service.

5. Indoor piping shall be ASJ max with SSL-II closure system as manufactured by Owens Corning, Johns Manville, Knauf or approved equal.

6. Exterior above ground piping shall be insulated with ASJ max SSL-II closure system insulation. Fiberglass insulation with aluminum jacketing shall be utilized for exterior above ground applications. Seal all aluminum jacketing laps with 1/8" bead of metal jacketing sealant to prevent water entry.

7. All floor drain piping that is indicated to receive A/C condensate shall be fully insulated to prevent condensation.

B. Equipment Insulation:

1. General:

a. Install insulation in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended purpose.

b. Install insulation on equipment after installation of heat tracing, painting, testing, and acceptance tests.

c. Install insulation materials with smooth, even surfaces. Rework poorly fitted joints. Do not use joint sealer or mastic as filler for joint gaps and excessive voids resulting from poor workmanship. Apply insulation using staggered joint method for both single and double layer installation, applying each layer of insulation separately.

d. Coat insulated surfaces where specified on contract drawings with layer of insulating cement, troweled in a workmanlike manner, leaving a smooth and continuous surface. Fill in seams, broken edges, and depressions. Cover over wire mesh and joints with cement sufficiently thick to remove surface irregularities.

e. Maintain the integrity of factory-applied vapor barrier jacketing on all insulation, protecting it against puncture, tears or other damage. Seal all tears, punctures and other penetrations of equipment insulation facing.

f. Where specification calls for field-applied all-service vapor barrier jacketing, it shall be neatly fitted and tightly secured. Lap seams 2-inches (5cm) (min.). Seal all joints with adhesive. Tape with 3-inches (7.5cm) matching pressure-sensitive tape or 3-inch (7.5cm) glass fabric and vapor barrier coating.

g. On exposed equipment, locate insulation and cover seams in least visible location.

2. Removable Insulation: Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance, such as vessel covers, fasteners, flanges, frames accessories, manholes, handholes, cleanouts ASME stamp, and manufacturer nameplates.

3. Areas Left Uninsulated: Items such as manholes, handholes, clean-outs, ASME stamp, and manufacturers' nameplates should be left uninsulated unless omitting insulation would cause a condensation problem. When such is the case, provide removable insulation and appropriate tagging to identify the presence of these items. Provide neatly beveled edges at interruptions of insulation.

4. Equipment Exposed to Weather: Protect outdoor insulation from weather by installation of weather barrier mastic protective finish or jacketing as recommended by the jacketing manufacturer.

C. Ductwork Insulation:

1. General:

a. Before installing insulation, ensure that all seams and joints in ductwork have been sealed and leak tested by the contractor responsible for the duct system. Before applying duct insulation, air ducts shall be clean and dry.

b. Install insulation in accordance with manufacturer's published instructions and recognized industry practice to ensure that it will serve its intended purpose.

c. Install insulation materials with smooth and even surfaces. Butt joints firmly together to ensure complete and tight fit over surfaces to be covered.

d. Maintain the integrity of factory-applied vapor barrier jacketing on all insulation, protecting it against puncture, tears or other damage. All staples used on ductwork insulation shall be coated with suitable sealant to maintain vapor barrier integrity and covered with pressure sensitive vapor barrier tape and vapor barrier coating as specified.

e. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and exposed joints. All portions of duct designated to receive duct wrap shall be completely covered with duct wrap.

f. To ensure installed thermal performance, duct wrap insulation shall be cut to "stretch-out" dimensions. Maintain specified duct insulation thickness and vapor barrier at all fittings, obstructions, and duct flanges.

g. A 2-inch (50mm) piece of insulation shall be removed from the facing at the end of the piece of duct wrap to form an overlapping stapling and taping flap.

h. Install duct wrap insulation with facing outside so that the tape flap overlaps the insulation and facing at the other end of the piece of duct wrap. Adjacent sections of duct wrap insulation shall be tightly butted with the 2-inch (50mm) stapling and taping flap overlapping. If ducts are rectangular or square, install so insulation is not excessively compressed at corners. Seams shall be stapled approximately 6-inches (150mm) on center with 2-inch (13mm) (min) steel outward clinching staples.

i. Seams, joints and staples shall be sealed with pressure-sensitive tape matching the insulation facing (either plain foil or FRK backing stock) and glass fabric and vapor barrier coating. Cloth duct tape of any color or finish using reclaimed rubber adhesives shall not be utilized on duct wrap insulation. Adjacent sections of duct wrap shall be tightly butted with the 2-inch (50mm) tape flap overlapping.

j. Where rectangular ducts are 24-inch (600mm) in width or greater, duct wrap insulation shall be additionally secured to the bottom of the duct with mechanical fasteners such as pins and speed clip washers, spaced on 18-inch (425mm) centers (maximum) to prevent sagging of insulation.

k. Seal all tears, punctures and other penetrations of the duct wrap facing using one of the above methods to provide a vapor tight system.

l. Upon completion of installation of duct wrap and before operation is to commence, visually inspect the system and verify that it has been correctly installed.

m. Open all system dampers and turn on fans to blow all scraps and other loose pieces of material out of the duct system. Allow for a means for removal of such material.

n. Check the duct system to ensure that there are no air leaks through joints.

o. No ductwork insulation shall be supported utilizing tie wire or bailing wire. Penetrations of ductwork insulation vapor barrier are prohibited.

p. Bevel and terminate insulation at access doors. Paint edges with vapor barrier mastic.

q. Install insulation board between volume dampers and sheet metal standoffs.

r. Provide removable insulation section at all pitot tube traverse points. Insulation section shall contain tether that attaches to adjacent ductwork.

2. Penetrations: Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise specified.

3. Ductwork Exposed to Weather: Protect outdoor insulation from weather by installing outdoor weather barrier mastic or jacketing as recommended by the insulation manufacturer.

4. Rigid Insulation:

a. Rigid duct insulation may be impaled over welded pins and secured with insulation caps and washers matching the color of the vapor barrier facing. All seams shall be firmly butted and sealed with pressure-sensitive vapor barrier tape matching the facing and vapor barrier coating.

b. Corner angles shall be installed on all external corners of rigid duct insulation in exposed finished areas before jacketing, except oven and hood exhaust duct insulation, which shall have no corner angles.

5. Duct Wrap Insulation: Duct wrap insulation shall be applied with all joints butted firmly together. All joints in the insulation covering shall be sealed with adhesive. Duct wrap insulation shall be secured to bottom of rectangular or oval ducts over

24inches (60cm) wide with mechanical fasteners on 16-inch (40 cm) (approx.) centers to prevent sagging.

6. Duct Lining Insulation: Duct liner insulation shall be applied with all joints tightly butted using 90 percent coverage of adhesive meeting the requirements of ASTM C 916 plus mechanical fasteners spaced according to the liner manufacturer's schedule for the interior width of the plenum, housing, or air shaft. (Also refer to Division 23 Section, HVAC Air Distribution System.)

3.5. FIELD QUALITY ASSURANCE

A. Upon completion of all insulation work covered by this specification, visually inspect the work and verify that it has been correctly installed. This may be done while work is in progress, to assure compliance with requirements herein to cover and protect insulation materials during installation.

3.6. PROTECTION

A. Replace damaged insulation which cannot be satisfactorily repaired, including insulation with vapor barrier damage and moisture-saturated insulation.

B. The insulation contractor shall advise the general and/or the mechanical contractor as to requirements for protection of the insulation work during the remainder of the construction period, to avoid damage and deterioration of the finished insulation work.

3.7. SAFETY PRECAUTIONS

A. Insulation contractor's employees shall be properly protected during installation of all insulation. Protection shall include proper attire when handling and applying insulation materials, and shall include (but not be limited to) disposable dust respirators, gloves, hard hats, and eye protection.

B. The insulation contractor shall conduct all job site operations in compliance with applicable provisions of the Occupational Safety and Health Act, as well as with all state and/or local safety and health codes and regulations that may apply to the work.

3.8. INSULATION COVERING

A. Unless otherwise noted, all exposed duct and equipment insulation shall have a field applied PVC jacket cover neatly cut and pasted over ductwork and equipment insulation. PVC shall be high gloss white and shall be 20 mils thick.

B. Unless otherwise noted, all exposed pipe insulation required to be insulated shall be jacketed with a PVC Jacketing with fitting covers. PVC jacket shall be color fade resistant, white high gloss, U.S.D.A. authorized as manufactured by Proto Corporation or approved equal. PVC jacketing shall be high impact, ultraviolet resistant PVC. Minimum thickness shall be 20 mils, roll stock ready for shop or field cutting and forming.

C. Exposed areas include, but are not limited to, all mechanical equipment rooms/fan rooms, mezzanines, geothermal pump/equipment rooms, penthouses, kitchens, electric rooms, vaults, storage rooms, janitor closets, IDF rooms, fire pump rooms, and stairwells piping and ductwork, exposed in an occupied space.

D. Where PVC jackets are indicated, install with 1 inch overlap at longitudinal seams and end joints, for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

E. Exterior exposed pipe insulation required to be insulated shall be jacketed with a corrugated aluminum jacketing system as previously described. Seal all laps with 1/8” bead metal jacketing sealant.

END OF SECTION

DIVISION 23 SECTION 23 09 00
INSTRUMENTATION AND CONTROLS OF HVAC AND PLUMBING SYSTEMS
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SECTION 23 09 00 – INSTRUMENTATION AND CONTROLS OF HVAC AND PLUMBING SYSTEMS

PART 1. GENERAL

1.1. SUMMARY

A. For General Mechanical Requirements, see Division 23 Section, Common Work Results for HVAC, and Division 01 Sections.

B. Comply with all code requirements and fire safety requirements as specified in Division 23 Section, Common Work Results for HVAC.

C. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

D. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory wired controls.

E. The automatic temperature control system ATC and central control and monitoring system (CCMS) shall be electric/electronic direct digital control (DDC), Alerton as installed by Albireo Energy, Johnson Controls (Metasys), Johnson Controls FX (Facility Explorer) as installed by Modern Controls, Honeywell, Siemens, Automated Logic Corporation, Reliable Controls, Schneider Electric as installed by Tri-M, Advanced Power, Trane, and TAC Controls by Schneider Electric installed by Automation and Control Concepts or Niagara. All work associated with the automatic temperature control system shall be performed by personnel regularly and directly employed by the Automatic Temperature Controls Contractor. Control System shall be web based, allowing the client access via a standard web browser.

F. Coordinate controls with controlled equipment. Upon completion of the work, calibrate and adjust all controls for proper function. Electric wiring, including interlock wiring for all equipment shall be furnished and installed under this section. All electrical work shall conform to the applicable requirements of Division 26.

G. All automatic temperature control dampers, valves and separable wells for immersion elements furnished by the Control Manufacturer shall be installed by the Mechanical Contractor or his sheet metal subcontractor under the Control Manufacturer's supervision.

H. Reference is hereby made for this contractor to become familiar with Division 26 of these specifications. Familiarization is for coordination purposes only. The control contractor shall provide all necessary relays, contactors, interlock wiring etc. not provided under Division 26 for the automation of the ATC and CCMS systems as required by the sequence of operation and input/output schedule. The control contractor shall coordinate all requirements with the building Fire Alarm System. The control contractor shall provide all additional devices and interlock wiring required for the automation of the ATC system and monitoring of the CCMS system.

I. Furnish all labor, materials, software, equipment and services necessary for and incidental to furnishing and installing a complete direct digital control, automatic temperature control system to meet the requirements of the sequence of operation described on the Drawings.

J. Unless the necessary items are specified to be provided with mechanical equipment by Division 23, the ATC contractor shall coordinate with Division 23, Mechanical, and shall furnish and install all items necessary to meet the requirements of the Sequence of Operation and the Central Control and Monitoring System (CCMS) indicated on the drawings and as required in this specification.

K. The control system shall include all necessary and specified control equipment properly installed in accordance with the specifications and drawings and shall include, but not be limited to the automatic temperature control and energy management system of the following:

1. Air Handling Units
2. Airflow Monitoring Stations
3. Automatic Glycol Feeder
4. Building Facilities
5. Canopy Hoods
6. Carbon Dioxide Sensors
7. Condensate Overflow Safety Switches
8. Control Valves
9. Dewpoint Temperature Sensors
10. Differential Bypass Valves Transmitters
11. Dish Machine Exhaust Fan
12. Domestic Hot Water Systems
13. Domestic Booster Pump System
14. Domestic Water Consumption/Meters
15. Dual Temperature System/Coils
16. Ductless Heat Pump Units
17. Dryer Duct Booster Fans
18. Dual Temperature Coils
19. Duct Detector Fan Interlocks
20. Economizer Systems/Relief Air Dampers
21. Energy Recovery Ventilators
22. Elevator Sump Pumps
23. Electric Radiant Heat Panels
24. Electric Heating Equipment
25. Exterior Lighting Systems
26. Flow Measuring Stations
27. Flow Switches
28. Freeze Protection Pumps
29. General Exhaust Systems
30. Glycol Feed Systems
31. Geothermal Heat Pumps
32. Head Pressure Control Valves
33. Heat Pipes
34. Heating System
35. High Temperature Alarms
36. Hot Gas Re-heat Coils
37. Hydraulic Separator Tank
38. Kitchen Ventilation System

39. Make-up Water Systems Interlocks and Alarms
40. Make-up Air Units
41. Mechanical Room Heat and Ventilation Control
42. Miscellaneous interlocks required for gas systems, ventilation systems, etc.
43. Plumbing Systems
44. Pumps
45. Relief Air Fans/Dampers
46. Rooftop Units.
47. Radiant Heat Panels
48. Relative Humidity/Temperature Sensors
49. Sensors (i.e., temperature, relative humidity, CO_2, etc.)
50. Unit Heater Control
51. Variable Speed Drives
52. Ventilation Systems
53. Water Heaters
54. Water Source Heat Pumps
55. Water to Water Heat Pumps

L. All labor, material, equipment and software to meet the functional intent of the system, as specified herein and as shown on the drawings, shall be included. Drawings are diagrammatic only. Equipment and labor not specifically referred to herein or on the plans, that are required to meet the functional intent, shall be provided without additional cost to the owner.

M. Where equipment is specified to be provided by equipment manufacturer or where packaged controls are specified map out all points provided by the manufacturer so the same can be viewed by ATC system. As a minimum all points indicated in the point list and control diagram must be viewable and adjustable from the ATC system. Coordinate with equipment manufacturer.

1.2. DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Main tracking/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

H. UPS: Uninterruptible Power Supply.

I. NAE: Network Automated Engine.

1.3. SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
2. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
3. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
4. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
5. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
6. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
7. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

a. Water Temperature: Plus or minus 1 deg F (0.5 deg C).
b. Water Flow: Plus or minus 5 percent of full scale.
c. Water Pressure: Plus or minus 2 percent of full scale.
d. Space Temperature: Plus or minus 1 deg F (0.5 deg C).
e. Ducted Air Temperature: Plus or minus 1 deg F (0.5 deg C).
f. Outside Air Temperature: Plus or minus 2 deg F (1.0 deg C).
g. Dew Point Temperature: Plus or minus 3 deg F (1.5 deg C).
h. Temperature Differential: Plus or minus 0.25 deg F (0.15 deg C).
i. Relative Humidity: Plus or minus 5 percent.
j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
l. Air Pressure (Space): Plus or minus 0.01-inch wg (2.5 Pa).
m. Air Pressure (Ducts): Plus or minus 0.1-inch wg (25 Pa).
n. Carbon Dioxide: Plus or minus 50 ppm.
o. Electrical: Plus or minus 5 percent of reading.

1.4. 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 equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.5. COORDINATION

A. Coordinate location of temperature sensors, humidity sensors, CO_2 sensors, dewpoint sensors, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 28 Section, “Fire Alarm System” to achieve compatibility with equipment that interfaces with that system.

C. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

D. Coordinate equipment with Division 26 Section, Panelboards to achieve compatibility with starter coils and annunciation devices.

1. Coordinate equipment with Division 26 Section, Motor-Controllers to achieve compatibility with motor starters and annunciation devices.

1.6. WORK BY OTHERS

A. Automatic temperature control valves, air flow stations, pipe taps, flow meters, and separable wells for immersion elements furnished by the control manufacturer shall be installed by the mechanical contractor under the control manufacturer's supervision. The control contractor shall deliver to the mechanical contractor valves and wells for installation within the various systems.

B. All automatic dampers furnished by the control manufacturer shall be installed by the mechanical contractor under the control manufacturer's supervision.

1.7. QUALITY ASSURANCE

A. Supplier shall have an in-place support facility with technical staff, spare parts inventory and all necessary test and diagnostic equipment. The fully staffed and equipped office shall be within a 60 mile radius of the job site.

B. The systems shall be complete in all respects, and shall be installed by skilled personnel. The Control Contractor shall have a successful history in the installation and maintenance of automatic temperature control systems similar in size and performance to that specified herein.

C. Refer to Contract Drawings for sequences of operations, control diagrams, and points lists.

D. All electrical wiring in connection with the Automatic Temperature Control System shall be furnished and installed by the ATC Contractor. This shall include all interlock wiring between the air handling units, fans, pumps, heating systems, switches, dampers, heat pumps, energy recovery ventilators, geothermal units, ductless units, static pressure controllers, rooftop units, kitchen makeup air units, fluid flow measuring stations, airflow monitoring stations, etc.

E. Bids by wholesalers, contractors or franchised dealers or any other firm whose principal business is not that of manufacturing or installing automatic temperature control systems, shall not be acceptable. Bid documents that are not complete in their response to these documents or take exception to any of the capabilities defined within these documents shall not be acceptable.

F. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

G. 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.

H. Comply with ASHRAE 135 for DDC system components.

1.8. GUARANTEE AND INSTRUCTION

A. The control system including all components, system software, parts and assemblies herein specified shall be free from defects in workmanship and materials under normal use and service. After completion of the installation, the Control Manufacturer shall regulate and adjust all thermostats, control valves, control motors, and other equipment provided under this contract. If within two (2) years from the date of acceptance by Owner any of the equipment herein described is proved to be defective in workmanship or materials, it will be replaced or repaired at no additional cost to the Owner. The Control Manufacturer shall, after completion, provide any service incidental to the proper performance of the Control System under guarantees outlined above for a period of two (2) years. Normal maintenance of the system is not to be considered part of the guarantee. All corrective modifications made during warranty service periods shall be updated on all user documentation including "as-built" shop drawings and on user and manufacturer archived software disks.

B. The control contractor shall completely check out, calibrate and test all connected hardware to insure that the system performs in accordance with the approved specifications and sequences of operation submitted.

C. Upon completion of the work, the control drawings encased in heavy plastic shall be provided where directed. Layout shall show all control equipment and the function of each item indicated.

D. The temperature control contractor's office shall be within a 100 mile radius of the job site.

E. The contractor shall respond to the job site with qualified technicians within a 4 hour period for any emergency relating to the control system or energy management systems.

F. This agreement shall include emergency service during normal working hours.

1.9. SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams showing equipment, fans, pumps, coils, dampers, valves, and control devices.
3. Wiring Diagrams: Power, signal, and control wiring.
4. Details of control panel faces, including controls, instruments, and labeling.
5. Written description of sequence of operation.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Schedule of valves including flow characteristics.
8. DDC System Hardware:

    a. Wiring diagrams for control units with termination numbers.
    b. Schematic diagrams and floor plans for field sensors and control hardware.
    c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
10. Controlled Systems:

    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagram.
    d. Points list.

C. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with LonWorks or Bacnet.

D. Software and Firmware Operational Documentation: Include the following:

1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.
5. Software license required by and installed for DDC workstations and control systems.

E. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

F. Qualification Data: For Installer and manufacturer.

G. Field quality-control test reports.

H. Submit screen shots of ATC system graphics at substantial completion.

I. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section, Operation and Maintenance Data, and Division 23 Section, Common Work Results for HVAC include the following:

1. Maintenance instructions and lists of spare parts for each type of control device.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
5. Calibration records and list of set points.

J. Upon completion of the work, provide a complete set of “as-built" drawings and application software on CD, USB, or other type of electronic storage device. Drawings shall be provided in format as acceptable to the Owner’s files. Submit as-built drawings and specification to Owner's representative for review and approval prior to final project closeout.

1.10. SOFTWARE LICENSE AGREEMENT

A. The owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software. All software and hardware upgrades shall be included in two (2) year warranty period.

B. Software license agreement shall not apply on projects where existing ATC system is being extended.

C. Minimum of four (4) software license seats shall be provided. Storage of all software shall be coordinated with the Smyrna School District’s IT Manager.

1.11. ELECTRICAL SURGE PROTECTION

A. It is the responsibility of the ATC/FMS contractor to provide adequate surge protection for all wall mounted control panels required for this project.

1. Devices under surge protection shall be of design that loss of memory will not occur in the event of the surge protection device being activated due to surge/spike conditions.
2. Surge protection devices will be required to be hard wired, with the exception of peripheral devices that use standard 110VAC plugs for connections (i.e. Modems).
3. Surge protection devices are to be rated for 120 VAC single phase, 20 (or greater) amps capacity.
4. Surge Protection devices to include internal fuse protection, audible surge alarm

& LED indicators.

5. Surge protectors to have clamping voltage of 480V peak, maximum surge current rating of 50,000 amps. Unit to have NEMA 12 enclosure with wall mounting bracket and conduit connection.

1.12. TRAINING

A. The Automatic Temperature Controls (ATC) Contractor shall include in his bid, provisions for additional computer training at the company's regular school or training center. The ATC contractor shall include in his bid all costs associated with sending one (1) individual to the ATC contractors school for a period of not less than one (1) week. This training is in addition to the aforementioned training required under the General Provisions.

B. The training time period shall be coordinated with the school system's facility Engineer. The schedule training period shall be arranged at the owner's convenience.

C. Cost shall include all training material, instruction books, and two copies of video tape with sound DVD of training session.

D. Upon completion of the work, the Control Contractor shall have completely adjusted the entire control system. He shall arrange to instruct the Owner's representative on the operation of the control system for a period of not less than two (2) eight (8) hour days. All training shall be by the control contractor and shall utilize specified manuals and as-built documentation.

E. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain control systems and components.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Provide operator training on data display, alarm and status descriptors, requesting data, executing commands, calibrating and adjusting devices, resetting default values, and requesting logs. Include a minimum of 40 hours' dedicated instructor time on-site.
3. Review data in maintenance manuals. Refer to Division 01 Section, Contract Closeout.
4. Review data in maintenance manuals. Refer to Division 01 Section, Operation and Maintenance Data.
5. Schedule training with Owner, with at least seven days' advance notice.
6. Control Contractor shall also attend and participate in separate HVAC equipment systems training in addition to ATC training.

1.13. ALTERNATES

A. Refer to Division 01 Section, Alternates for description of work under this section affected by alternates.

1.14. SMYRNA SCHOOL DISTRICT SPECIFIC REQUIREMENTS

A. The ATC Subcontractor shall include in his bid all costs associated with incorporating the following specific requirements:

1. All holiday schedules shall incorporate a 12 month block. Coordinate exact holidays, schedules, calendars, occupied, unoccupied periods with Owner prior to writing software. All schedules shall be reviewed and approved by the Owner.
2. Relays for ATC equipment shall not be located in ceilings. All relays shall be located in equipment control panels and/or mechanical rooms.
3. All exhaust fans shall be assigned a designated point. Utilizing relays to provide digital point for exhaust fans shall not be acceptable.
4. Graphics on ATC computer shall in addition to basic requirements indicate the percentage open or closed on all valves and dampers.
5. The ATC Computer Graphics shall incorporate the final room numbers actually utilized in the Sunnyside Intermediate School. All room names utilized in the graphic display shall be reviewed and approved by the Owner.
6. The ATC Computer Graphics shall indicate for each item of equipment the "on" or "off" status and command shall be "run" or "stop".
7. The ATC Computer Graphic shall indicate for each duct smoke detector the "on" or "off" status and command.
8. All temperature sensors, equipment, relative humidity sensors, dewpoint temperature sensors, current sensors, CO2 sensors, differential pressure sensors, etc. indicated on ATC Control Diagrams and point list shall be displayed on the ATC Computer Graphic. Measured value or status shall be displayed.
9. For any multi-stage HVAC units, the quantity of compressor stages and the quantity of electric heat stages shall be displayed on the Computer Graphics.
10. The exact space temperature set points, relative humidity set points, changeover set points. etc., shall be coordinated with Owner prior to final data entry. All items indicated in sequences of Operation as "adjustable" shall be reviewed and approved by Owner prior to implementation of the same.
11. The outside air relative humidity and outside air temperature shall be monitored on ATC system and reported on ATC Computer Graphics. See Floor plans for exact locations.
12. Provide a graphic of all floor plans indicating location of all equipment interlocked with ATC System including all control panels.
13. Graphic shall also indicate area of building served by each item of equipment. Graphics shall indicate all global sensor readings.
14. For the dual temperature system and the geothermal system provide a single command on the control system to allow all control valves to be manually opened for balancing by activating a single command.
15. All equipment shall be labeled with name of equipment, area served, and area location (room name/number).
16. Scheduling of HVAC equipment/zones shall be such that for afterhours use the ATC system shall allow a temporary override of the pre-set occupied/unoccupied schedule by zone and for specific equipment in a zone. This must allow the school staff the ability to operate as few or many zones as desired without operating entire portions of the building.
17. Provide "Loss of Heat" monitoring and alarm on ATC system if any space temperature sensor in the building drops below 50 degrees Fahrenheit (Adjustable).
18. Provide additional software package and license so that Owner can install software on Owner provided laptop. Assist owner with installation of software.
19. Provide a "demand toggle control" switch on ATC system to automatically reduce HVAC electric demand (power) by automatically modifying setpoints to pre-

determined values. Coordinate pre-determined setpoint values with Owner and document in the As-Built Documents.

20. Scheduling of HVAC equipment/zones shall be such that for afterhours use the ATC system shall allow a temporary override of the pre-set occupied/unoccupied schedule by zone and for specific equipment in a zone. This must allow the Smyrna School District the ability to operate as few or many zones as desired without operating entire portions of the building.
21. Alarms shall be delayed during optimal start stop to avoid nuisance alarm triggers.
22. Position of all H-O-A switches and other switches shall be reported on ATC graphic with equipment.
23. All text alarms shall clearly identify what they are within the body of the text. i.e. “freeze protection pump failure”, “ERV XX-“, “Duct smoke detector trip”, etc. Coordinate all text alarms and verbiage with Owner.

1.15. GLOBAL SENSORS

A. General

1. Furnish and install global sensors and report the same on the automatic temperature control system.
2. Global sensors shall monitor and trend the following conditions:

a. Outside air temperature.
b. Outside air relative humidity.
c. Outside Air CO_2 level in ppm.
d. Geothermal supply water temperature.
e. Geothermal return water temperature.
f. Dual temperature supply water temperature.
g. Dual temperature return water temperature.
h. All ventilation fan speeds where variable frequency drives are specified.
i. Outside air carbon dioxide level.
j. All ventilation fan amperage where variable frequency drives are specified.
k. All pump or fan speeds where variable frequency drives are specified.
l. All pump amperage's where variable frequency drives are specified.
m. All fan amperages where variable speed fans are indicated. Graphic shall also indicate area of building served by each item of equipment.
n. Kitchen walk-in refrigerator and freezer space temperatures.
o. Main Distribution Frame (MDF), and I.T. server room space temperature sensor.
p. Global holiday schedules:

i. Provide all interlock wiring and programming to allow a global holiday schedule for all equipment except the administration equipment. Global holiday schedule shall allow the Owner to shut down the entire building’s HVAC systems if an unscheduled event occurs when school is cancelled.
ii. System shall also be capable of individual scheduling of equipment as specified or all can be globally modified at once.

q. All equipment interlocked with ATC system shall be able to be turned on/off via ATC system as specified. Changing temperature set point alone is not acceptable method for turning equipment on/off.

r. Where valve or damper position is indicated ATC graphic shall indicate percentage open or percentage closed.

PART 2. PRODUCTS

2.1. BUILDING MANAGEMENT SYSTEM

A. The Building Management System (BMS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BMS shall support open communication protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other owner provided networks.

B. The Building Management System shall consist of the following:

1. Standalone Network Automation Engine(s)
2. Field Equipment Controller(s)
3. Input/Output Module(s)
4. Local Display Device(s)
5. Portable Operator's Terminal(s)
6. Distributed User Interface(s)
7. Network processing, data storage and communications equipment
8. Other components required for a complete and working BMS

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.

D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

E. Automation Network

1. The automation network shall be based on a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard “off the shelf” products available through normal PC vendor channels.
2. The automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.
3. Network Automation Engines (NAE) and/or system controllers shall reside on the automation network.
4. The automation network will be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.

F. Control Network

1. Network Automation Engines and/or system controllers shall provide supervisory control over the control network and shall support all three (3) of the following communication protocols:

    a. BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9.
    b. LonWorks enabled devices using the Free Topology Transceiver (FTT-10a).
    c. The Johnson Controls N2 Field Bus or equivalent.
    d. Tridium FX-40
    e. Honeywell Webs
    f. TAC Controls by Schneider Electric
    g. Siemens P1/P2 Serial

2. Control networks shall provide either "Peer-to-Peer," Main-Tracking, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 9600 baud.
3. DDC Controllers shall reside on the control network.
4. Control network communication protocol shall be BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135.
5. A BACnet Protocol Implementation Conformance Statement shall be provided for each controller device (main or tracking) that will communicate on the BACnet MS/TP Bus.
6. The Conformance Statements shall be submitted with the BAS Submittals.

G. Integration

1. Hardwired

    a. Analog and digital signal values shall be passed from one system to another via hardwired connections.
    b. There will be one separate physical point on each system for each point to be integrated between the systems.

2. BACnet Protocol Integration – BACnet

    a. The neutral protocol used between systems will be BACnet over Ethernet and comply with the ASHRAE BACnet standard 135-2003.
    b. A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.
    c. The ability to command, share point object data, change of state (COS) data and schedules between the host and BACnet systems shall be provided.

H. Dedicated Web Based User Interface

1. Where required by the Owner, the BMS Contractor shall provide and install a personal computer for command entry, information management, network alarm management, and database management functions. All real-time control functions, including scheduling, history collection and alarming, shall be resident in the BMS Network Automation Engines to facilitate greater fault tolerance and reliability. Coordinate with Owner to determine computer type (i.e. PC (Windows based) or

Macintosh (Apple)).

2. Dedicated User Interface Architecture – The architecture of the computer shall be implemented to conform to industry standards, so that it can accommodate applications provided by the BMS Contractor and by other third party applications suppliers, including but not limited to Microsoft Office Applications. Specifically it must be implemented to conform to the following interface standards.

   a. Microsoft Internet Explorer for user interface functions
   b. Microsoft Office Professional for creation, modification and maintenance of reports, sequences other necessary building management functions
   c. Microsoft Outlook or other e-mail program for supplemental alarm functionality and communication of system events, and reports
   d. Required network operating system for exchange of data and network functions such as printing of reports, trends and specific system summaries.

3. Computer Hardware – The personal computer(s) shall be configured as follows:

   a. Description: A tower or all-in-one computer designed for normal use at a single, semipermanent location.
   b. Performance Requirements:

      i. Performance requirements may dictate equipment exceeding minimum requirements indicated.
      ii. Energy Star compliant.

   c. Personal Computer:

      i. Minimum Processor Speed: 3 gigahertz (GHz). Dual Core Processer.

   d. RAM:

      i. Capacity: 16GB.
      ii. Speed and Type: 1333 MHz, SDRAM.

   e. Hard Drive:

      i. Media: Solid state.
      ii. Number of Hard Drives: One.
      iii. Capacity: 250GB.

   f. Optical Read and Write Drive:

      i. Include with at least 2 MB of data buffer.
      ii. Type: SCS1 CD-ROM Drive with Read/Write Capability.
      iii. Average access time of 150 ms or less.

   g. At least four expansion slots.
   h. Video Card:

i. Resolution: 1920 by 1200 pixels.
ii. RAM: 4 GB.
iii. Controller Speed: 4GHz.

i. Sound Card:

i. At least 128 voice wavetable synthesis.
ii. Capable of delivering three-dimensional sound effects.
iii. High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.

j. Two (2) Network Interface Cards: Include cards with connection, as applicable.

i. 10-100-1000 base TX Ethernet with RJ45 connector port.
ii. 100 base FX Ethernet with SC or ST port.

k. Wireless Ethernet, 802.11 a/b/g/n.
l. Optical Modem: Full duplex link for connection to optical fiber cable provided.
m. I/O Ports:

i. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
ii. One serial port.
iii. One parallel port.
iv. Two PS/2 ports.
v. One RJ-45.
vi. One stereo line-in and headphone/line-out on back panel.
vii. One microphone and headphone connector on front panel.
viii. One IEEE 1394 on front and back panel with PCI-e card.
ix. One ESATA port on back panel.

n. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.
o. Keyboard:

i. 101 enhanced keyboard.
ii. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
iii. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

p. Pointing Device:

i. Either a two- or three-button mouse.
ii. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

q. Flat Panel Display Monitor:

i. Display:
  1. Color display with 21 inches diagonal viewable area.
  2. Digital input signal.
  3. Aspect Ratio: 16 to 9.
  4. Antiglare display.
  5. Tilt adjustable base.
  6. Energy Star compliant.
  7. Resolution: 1920 by 1200 pixels at 60 Hz.
  8. Number of Displays: One.

r. Speakers:

  i. Two, with individual controls for volume, bass and treble.
  ii. Signal to Noise Ratio: At least 65 dB.
  iii. Power: At least 4 W per speaker/channel.
  iv. Magnetic shielding to prevent distortion on the video monitor.

s. I/O Cabling: Include applicable cabling to connect I/O devices.
t. Uninterruptable Power Supply.

I. User Interface Application Components

1. Operator Interface

a. An integrated browser based client application shall be used as the user operator interface program.
b. All Inputs, Outputs, Setpoints, and all other parameters as defined within Part 3 or on the drawings, shown on the design drawings, or required as part of the system software, shall be displayed for operator viewing and modification from the operator interface software.
c. The user interface software shall provide help menus and instructions for each operation and/or application.
d. All controller software operating parameters shall be displayed for the operator to view/modify from the user interface. These include: setpoints, alarm limits, time delays, PID tuning constants, run-times, point statistics, schedules, and so forth.
e. The Operator Interface shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:

  i. User access for selective information retrieval and control command execution
  ii. Monitoring and reporting
  iii. Alarm, non-normal, and return to normal condition annunciation
  iv. Selective operator override and other control actions
  v. Information archiving, manipulation, formatting, display and reporting
  vi. FMS internal performance supervision and diagnostics
  vii. On-line access to user HELP menus
  viii. On-line access to current FMS as-built records and documentation
  ix. Means for the controlled re-programming, re-configuration of FMS operation and for the manipulation of FMS database

information in compliance with the prevailing codes, approvals and regulations for individual FMS applications.

x. The operation of the control system shall be independent of the user interface, which shall be used for operator communications only. Systems that rely on an operator workstation to provide supervisory control over controller execution of the sequences of operations or system communications shall not be acceptable.

2. Navigation Trees

a. The system will have the capability to display multiple navigation trees that will aid the operator in navigating throughout all systems and points connected. At minimum provide a tree that identifies all systems on the networks.

b. Provide the ability for the operator to add custom trees. The operator will be able to define any logical grouping of systems or points and arrange them on the tree in any order. It shall be possible to nest groups within other groups. Provide at minimum 5 levels of nesting.

c. The navigation trees shall be "dockable" to other displays in the user interface such as graphics. This means that the trees will appear as part of the display, but can be detached and then minimized to the Windows task bar or closed altogether. A simple keystroke will reattach the navigation to the primary display of the user interface.

3. Alarms

a. Alarms shall be routed directly from Network Automation Engines to PCs and servers. It shall be possible for specific alarms from specific points to be routed to specific PCs and servers. The alarm management portion of the user interface shall, at the minimum, provide the following functions:

i. Log date and time of alarm occurrence.

ii. Generate a "Pop-Up" window, with audible alarm, informing a user that an alarm has been received.

iii. Allow a user, with the appropriate security level, to acknowledge, temporarily silence, or discard an alarm.

iv. Provide an audit trail on hard drive for alarms by recording user acknowledgment, deletion, or disabling of an alarm. The audit trail shall include the name of the user, the alarm, the action taken on the alarm, and a time/date stamp.

v. Provide the ability to direct alarms to an e-mail address or alphanumeric pager. This must be provided in addition to the pop up window described above. Systems that use e-mail and pagers as the exclusive means of annunciating alarms are not acceptable.

vi. Any attribute of any object in the system may be designated to report an alarm.

b. The FMS shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions

c. The FMS shall annunciate application alarms as required.

4. Reports and Summaries

a. Reports and Summaries shall be generated and directed to the user interface displays, with subsequent assignment to printers, or disk. As a minimum, the system shall provide the following reports:

i. All points in the BMS
ii. All points in each BMS application
iii. All points in a specific controller
iv. All points in a user-defined group of points
v. All points currently in alarm
vi. All points locked out
vii. All BMS schedules
viii. All user defined and adjustable variables, schedules, interlocks and the like.

b. Summaries and Reports shall be accessible via standard UI functions and not dependent upon custom programming or user defined HTML pages.
c. Selection of a single menu item, tool bar item, or tool bar button shall print any displayed report or summary on the system printer for use as a building management and diagnostics tool.
d. The system shall allow for the creation of custom reports and queries via a standard web services XML interface and commercial off-the-shelf software such as Microsoft Access, Microsoft Excel, or Crystal Reports.

5. Schedules

a. A graphical display for time-of-day scheduling and override scheduling of building operations shall be provided. At a minimum, the following functions shall be provided:

i. Weekly schedules
ii. Exception Schedules
iii. Monthly calendars

b. Weekly schedules shall be provided for each group of equipment with a specific time use schedule.
c. It shall be possible to define one or more exception schedules for each schedule including references to calendars
d. Monthly calendars shall be provided that allow for simplified scheduling of holidays and special days for a minimum of five years in advance. Holidays and special days shall be user-selected with the pointing device or keyboard, and shall automatically reschedule equipment operation as previously defined on the exception schedules.
e. Changes to schedules made from the User Interface shall directly modify the Network Automation Engine schedule database.
f. Schedules and Calendars shall comply with ASHRAE SP135/2003 BACnet Standard.
g. Selection of a single menu item or tool bar button shall print any displayed schedule on the system printer for use as a building management and diagnostics tool.

6. Password

a. Multiple-level password access protection shall be provided to allow the user/manager to user interface control, display, and database manipulation capabilities deemed appropriate for each user, based on an assigned password.
b. Each user shall have the following: a user name (24 characters minimum), a password (12 characters minimum), and access levels.
c. The system shall allow each user to change his or her password at will.
d. When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.
e. A minimum of five levels of access shall be supported individually or in any combination as follows:

    i. Level 1 = View Data
    ii. Level 2 = Command
    iii. Level 3 = Operator Overrides
    iv. Level 4 = Database Modification
    v. Level 5 = Database Configuration
    vi. Level 6 = All privileges, including Password Add/Modify

f. A minimum of 100 unique passwords shall be supported.
g. Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.
h. The system shall automatically generate a report of log-on/log-off and system activity for each user. Any action that results in a change in the operation or configuration of the control system shall be recorded, including: modification of point values, schedules or history collection parameters, and all changes to the alarm management system, including the acknowledgment and deletion of alarms.

7. Screen Manager - The User Interface shall be provided with screen management capabilities that allow the user to activate, close, and simultaneously manipulate a minimum of 4 active display windows plus a network or user defined navigation tree.
8. Dynamic Color Graphics

    a. The graphics application program shall be supplied as an integral part of the User Interface. Browser or Workstation applications that rely only upon HTML pages shall not be acceptable.
    b. The graphics applications shall include a create/edit function and a runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed.
    c. The graphics shall be able to display and provide animation based on real-time data that is acquired, derived, or entered.
    d. Graphics runtime functions – A maximum of 16 graphic applications shall be able to execute at any one time on a user interface or workstation with 4 visible to the user. Each graphic application shall be capable of the following functions:

        i. All graphics shall be fully scalable

ii. The graphics shall support a maintained aspect ratio.
iii. Multiple fonts shall be supported.
iv. Unique background shall be assignable on a per graphic basis.
v. The color of all animations and values on displays shall indicate the status of the object attribute.

e. Operation from graphics – It shall be possible to change values (setpoints) and states in system controlled equipment by using drop-down windows accessible via the pointing device

f. Graphic editing tool – A graphic editing tool shall be provided that allows for the creation and editing of graphic files. The graphic editor shall be capable of performing/defining all animations, and defining all runtime binding.

i. The graphic editing tool shall in general provide for the creation and positioning of point objects by dragging from tool bars or drop-downs and positioning where required.
ii. In addition, the graphic editing tool shall be able to add additional content to any graphic by importing backgrounds in the SVG, BMP or JPG file formats.

g. Aliasing – Many graphic displays representing part of a building and various building components are exact duplicates, with the exception that the various variables are bound to different field values. Consequently, it shall be possible to bind the value of a graphic display to aliases, as opposed to the physical field tags.

9. Historical trending and data collection

a. Each Automation Engine shall store trend and point history data for all analog and digital inputs and outputs, as follows:

i. Any point, physical or calculated, may be designated for trending. Two (2) methods of collection shall be allowed:
1. Defined time interval
2. Upon a change of value.

ii. Each Automation Engine shall have the capability to store multiple samples for each physical point and software variable based upon available memory, including an individual sample time/date stamp. Points may be assigned to multiple history trends with different collection parameters.

b. Trend and change of value data shall be stored within the engine and uploaded to a dedicated trend database or exported in a selectable data format via a provided data export utility. Uploads to a dedicated database shall occur based upon one of the following: user-defined interval, manual command, or when the trend buffers are full. Exports shall be as requested by the user or on a time scheduled basis. Trend data shall be available for a minimum of twelve (12) months.

10. Trend data viewing and analysis

    a. Provide a trend viewing utility that shall have access to all database points.
    b. It shall be possible to retrieve any historical database point for use in displays and reports by specifying the point name and associated trend name.
    c. The trend viewing utility shall have the capability to define trend study displays to include multiple trends
    d. Displays shall be able to be single or stacked graphs with on-line selectable display characteristics, such as ranging, color, and plot style.
    e. Display magnitude and units shall both be selectable by the operator at any time without reconfiguring the processing or collection of data. This is a zoom capability.
    f. Display magnitude shall automatically be scaled to show full graphic resolution of the data being displayed.
    g. Trend studies shall be capable of calculating and displaying calculated variables including highest value, lowest value and time based accumulation.

J. Network Automation Engine (NAE)/ System Controllers

1. The Network Automation Engine (NAE)/ System Controllers or approved equal shall be a fully user-programmable, supervisory controller. The NAE shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Automation Engines.
2. Automation network – The NAE shall reside on the automation network and shall support a subnet of system controllers.
3. User Interface – Each NAE shall have the ability to deliver a web based User Interface (UI) as previously described. All computers connected physically or virtually to the automation network shall have access to the web based UI.

    a. The web based UI software shall be imbedded in the NAE. Systems that require a local copy of the system database on the user's personal computer are not acceptable.
    b. The NAE shall support up four (4) concurrent users.
    c. The web based user shall have the capability to access all system data through one NAE.
    d. Remote users connected to the network through an Internet Service Provider (ISP) or telephone dial up shall also have total system access through one NAE.
    e. Systems that require the user to address more than one NAE to access all system information are not acceptable.
    f. The NAE shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the NAE.
    g. Systems that support UI Graphics from a central database or require the graphics to reside on the user's personal computer are not acceptable.
    h. The web based UI shall support the following functions using a standard version of Microsoft Internet Explorer:

        i. Configuration

ii. Commissioning
iii. Data Archiving
iv. Monitoring
v. Commanding
vi. System Diagnostics

i. Systems that require workstation software or modified web browsers are not acceptable.
j. The NAE shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.

4. Processor – The NAE shall be microprocessor-based with a minimum word size of 32 bits. The NAE shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. NAE size and capability shall be sufficient to fully meet the requirements of this Specification.
5. Memory – Each NAE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.
6. Hardware Real Time Clock – The NAE shall include an integrated, hardware-based, real-time clock.
7. The NAE shall include troubleshooting LED indicators to identify the following conditions:

a. Power - On/Off
b. Ethernet Traffic – Ethernet Traffic/No Ethernet Traffic
c. Ethernet Connection Speed – 10 Mbps/100 Mbps
d. FC Bus – Normal Communications/No Field Communications
e. Peer Communication – Data Traffic Between NAE Devices
f. Run – NAE Running/NAE In Startup/NAE Shutting Down/Software Not Running
g. Bat Fault – Battery Defective, Data Protection Battery Not Installed
h. Fault – General Fault
i. Modem RX – NAE Modem Receiving Data
j. Modem TX – NAE Modem Transmitting Data

8. Communications Ports – The NAE shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator's terminals.

a. Up to two (2) USB port
b. Up to two (2) URS-232 serial data communication port
c. Up to two (2) RS-485 port
d. One (1) Ethernet port

9. Diagnostics – The NAE shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Network Automation Engine shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.
10. Power Failure – In the event of the loss of normal power, The NAE shall continue to operate for a user adjustable period of up to 10 minutes after which there shall

be an orderly shutdown of all programs to prevent the loss of database or operating system software.

a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.
b. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.

11. Certification – The NAE shall be listed by Underwriters Laboratories (UL).
12. Controller network – The NAE shall support the following communication protocols on the controller network:

a. The NAE shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.

i. A BACnet Protocol Implementation Conformance Statement shall be provided for each controller device (main or tracking) that will communicate on the BACnet MS/TP Bus.
ii. The Conformance Statements shall be submitted 10 day prior to bidding.
iii. The NAE shall support a minimum of 100 control devices.

b. The NAE shall support the Johnson Controls N2, Tridium FX-40, or Honeywell Webs or approved equal Field Bus.

i. The NAE shall support a minimum of 100 N2 control devices.
ii. The Bus shall conform to Electronic Industry Alliance (EIA) Standard RS-485.
iii. The Bus shall employ a main/tracking protocol where the NAE is the main.
iv. The Bus shall employ a four (4) level priority system for polling frequency.
v. The Bus shall be optically isolated from the NAE.
vi. The Bus shall support the Metasys Integrator System.

2.2. WIRING

A. The multi-conductor cable for field wiring of electronic analog sensors shall be minimum No. 22 AWG, 300 volt, thermoplastic with stranded copper wire and 100 percent shield coverage. The number of conductors in each sensor cable shall be as determined by the Contractor. 2/c #22 shielded cables shall be Belden Cat. #8451 3/c #20 shielded cables shall be Belden Cat. #9770 or approved equal.

B. Conductors for digital sensors or contact control shall be the same as for the analog sensors, except the grounded shield is not required.

C. Individual conductors shall be color coded and in addition shall be numbered in the field to identify the particular terminal to which attached. Field numbering shall be performed with Brady or approved equal markers wrapped around the wire near the terminal connection. All wires shall be terminated with pressure type connectors suitable for wire size, material and terminal connection.

D. All exposed wiring or wiring concealed in partitions shall be installed in a designated conduit raceway. The conduit shall conform to Division 26 of the specification. Where wiring is installed in an air plenum the same shall be plenum rated cable.

E. All junction boxes shall have covers painted safety green, and be rigid steel.

F. All wiring between differential pressure transmitters and variable frequency drive pump controllers shall be shielded and grounded at the pump controller end. Directly route the variable frequency drive pump controller to the differential pressure transmitter(s).

G. All wiring between static pressure controllers and/or air flow monitoring stations and variable frequency drive fan controllers shall be shielded and grounded at the fan controller end. Directly route the variable frequency drive fan controller to the static pressure controller(s) and/or air flow monitoring stations.

H. Where a motor disconnect is indicated downstream of a variable frequency drive (VFD) provide interlock wiring from the auxiliary contacts on the disconnect to the VFD to de-energize when the disconnect is turned “off”.

2.3. CONTROLLERS

A. Temperature, relative humidity, and CO2 sensor covers shall be stainless steel wire guard type with vandal proof screws. All room relative humidity, CO2, and temperature sensors shall be mounted 4'-0 inches above the finished floor, except in stairways, corridors and toilets, which shall be 7'-0 inches. Provide insulating bases where temperature sensors are located on exterior or unconditioned walls. Each temperature sensor shall have adjustable limit stops and adjustable sensitivity. User adjustment shall be 2 degrees F above and below set points or as determined by the Owner. Room temperature sensors shall include range of 55 degrees F to 85 degrees F set point adjustment. Temperature sensors shall include set-point adjustors, U.L. approved for mounting base in air plenums, and RJ-11 jack for communications. Room temperature sensors shall be fully adjustable and shall display set point and actual temperature.

B. Low Limit Thermostats: Freezestats shall have a minimum 20 foot (averaging sensing element) capillary tube sized to the basis of one linear foot of capillary tube for each square foot of coil surface. Thermostat sensitivity shall be adjustable. Freezestats shall stop all fans and close the outside air damper if air temperature drops below 35 degrees F and open hot water heating valves. Low limit thermostats shall include hardwire interlock to fans and the building automatic control system. Low limit thermostats shall remain active even when H-O-A switches are in “HAND”. Additional requirements are indicated in Sequence of Operation.

C. Room temperature sensors shall be accessible to ADA occupants.

D. All global sensors shall be monitored in accessible locations. Exterior sensors shall be provided with sun shield and be installed to prevent bird nesting.

2.4. DAMPERS

A. Control Dampers

1. The temperature control contractor shall provide all automatic control dampers of the types indicated on the plans and not specified to be integral with other equipment. Frames shall be not less than 16 gauge galvanized steel. Blades shall not be over 6 inches wide airfoil shaped double skin construction of 14 gauge equivalent thickness. Bearings shall be stainless steel sleeves with 2 inch shafts. Blade edge seals shall be vinyl blade with flexible metal compressible jamb seals of the tight-seal spring type. Dampers and seals shall be suitable for temperature ranges of -40 to 250 degrees F.
2. All proportional control dampers shall be opposed blade type and all two-position dampers shall be parallel blade type.
3. Dampers shall be sized to meet flow requirements of the application. The sheet metal contractor shall furnish and install baffles to fit the damper to duct size. Baffles shall not exceed 6 inches.
4. Dampers shall be minimum leakage type to conserve energy and the temperature control manufacturer shall submit leakage and flow characteristic data for all control dampers with the temperature control submittal. Maximum leakage shall be 3 CFM/Sq. Ft. at static pressure of 1 inch W.C. for a damper width of 48 inches.
5. Ultra-low leakage dampers shall have blade edges shall to be fitted with replaceable, snap-on, inflatable seals to limit damper leakage to 2 percent at applied static pressure.
6. Medium and Low pressure rectangular control dampers shall be Type CD60 airfoil low leakage damper as manufactured by Ruskin or as approved equal of American Warming and Ventilating, Air Balance and Arrow.
7. Round control dampers shall be Type CERS25 with blade edge seals as manufactured by Ruskin or as approved equal.
8. Provide damper end switch for all control dampers where indicated. Damper end switch shall be independent of the damper actuator and shall provide “proof of open” prior to allowing fan to energize. Damper end switch shall be Model TS-475 Mechanical Damper Arm Switch (no-mercury) as manufactured by MDI, Inc. or approved equal. Install per manufacturer’s recommendations on control damper. End switch shall have the following features:

    a. Housing Material: Glass filled PBT (polybutylene terephthalate).
    b. Bracket Material: Plated steel.
    c. Operation: Steel ball actuated sub-miniature snap action switch.
    d. Operating angle: 15 degrees. (Contact closes at 10 degrees above horizontal and contact opens at 5 degrees below horizontal).

B. Duct Smoke Detectors

1. Duct Smoke detectors shall be provided by the Electrical Contractor and installed by the Mechanical Contractor. All wiring, interlocks, etc., to be provided by Electrical Contractor. Wiring from duct smoke detectors to fans shall be by ATC Contractor. Duct smoke detectors shall be tested by the Test and Balance Engineer as specified in Division 23 Section, Testing Adjusting & Balancing for HVAC and Plumbing.

C. Damper Operators

1. Electric damper actuators shall be properly sized to provide sufficient torque to position the damper throughout its operating range.
2. Use devices which are quiet in operation and which in the event of power failure, will "fail safe" by spring action in either the normally open or normally closed position as required for freeze, moisture, smoke, or fire protection.
3. Electric actuators requiring a 24 VAC power supply will be utilized. Motors shall be specifically designed and sized with proper torque according to requirements of the device it is to be used on (i.e.: valve, damper). Each actuator will accept the proper control input as the system is designed, (i.e.: floating, 0-10VDC, 4-20Ma etc.) without the need for any additional interface devices.
4. For all exterior damper operators provide NEMA 4X stainless steel corrosion resistant enclosure. Damper operator enclosure shall be model ZS-300 as manufactured by Belimo or approved equal.

2.5. CONVENTIONAL HYDRONIC CONTROL VALVES-CONVENTIONAL GEOTHERMAL WATER SOURCE HEAT PUMPS

A. All automatic control valves 2 inches and smaller shall be screwed type, and valves 2 ½ inches and larger shall be flanged. Valves shall be factory-rated to withstand the pressures encountered. Valves shall have stainless-steel stems and spring loaded Teflon packing with replaceable seats and discs. All control valves must be capable of withstanding the shut-off head of the pump, they are connected to without the valve seat lifting. Valves shall have stainless steel stems and spring loaded Teflon packing with replaceable seats and discs.

1. All modulating straight-through water valves shall be provided with equal-percentage contoured throttling plugs. All three-way valves shall be provided with linear throttling plugs such that the total flow through the valve shall remain constant regardless of the valve's position modulating. Valves shall be sized for a pressure drop equal to the coil they serve but not to exceed 5 psi. Valves shall have replaceable seats and discs.
2. Where applicable, all two (2) position (i.e. “open”/ “closed”) control valves may be furnished with hose kits at Contractor's option. Coordinate actuator and pressure drop requirements with hose kit supplier. Maximum allowable pressure drop for two (2) position control valves shall be 3 feet at scheduled flow rate. Control valves used for non-modulating applications (i.e. “open” / “closed”) shall be full line size not reduced in size due to the lack of need for value authority
3. Optional accessories shall include a stem packing lubricator for factory or field assembly. Valve stem packing shall be low friction, tight sealing Teflon.
4. Unitary valves shall be straight-through or three way type as specified in the sequence of operation with high-pressure connections suitable for copper pipe and rated for 250 psig. Stems shall be polished stainless-steel and packing shall be ethylene-propylene suitable for both chilled water and 250 degree hot water service. Straight-through valves shall have back-seating feature, to allow packing to be replaced without draining system.
5. All valves shall use guided valve plugs for good seating and reliable operation. Valves ½ inch to 1 inch shall be ANSI Class 125 brass body with screwed ends. Valves 1-1/4 inches to 2 inches shall be ANSI Class 150 brass body with screwed ends. Valves 2-1/2 inches to 4 inches shall be Class 125 cast iron body with bronze

trim and flanged ends. Valves 6 inches and larger shall be Class 125 steel body with bronze trim and flanged ends. Butterfly valves shall be DeZurick HIGH performance or Keystone Keylock, Lug style as specified in Division 23 Section, HVAC Piping, Fittings, and Valves.

6. All heat pump valves shall be normally open to the coil.

B. Control Valve Operators

1. Electric valve actuators shall be properly sized to provide sufficient torque to position valves throughout its operating range.
2. Use devices which are quiet in operation and which in the event of power failure, will "fail safe" by spring action in either the normally open or normally closed position as required for freeze, moisture, smoke, or fire protection. Spring return valves are required for all control valves where coils are exposed to outside air conditions.
3. Electric actuators requiring a 24VAC power supply will be utilized. Motors shall be specifically designed and sized with proper torque according to requirements of the device it is to be used on (i.e: valve, damper). Each actuator will accept the proper control input as the system is designed, (i.e.: floating, 0-10VDC, 4-10Ma etc.) without the need for any additional interface devices.

2.6. PRESSURE INDEPENDENT HYDRONIC CONTROL VALVES – ALL DUAL TEMPERATURE CONTROL VALVES, AND GEOTHERMAL SYSTEM HEAD PRESSURE CONTROL VALVES

A. All automatic control valves 2 inches and smaller shall be screwed type, and valves 2 ½ inches and larger shall be flanged. Valves shall be factory-rated to withstand the pressures encountered. Valves shall have stainless-steel stems and spring loaded Teflon packing with replaceable seats and discs. All control valves must be capable of withstanding the shut-off head of the pumps, they are connected to without the valve seat lifting. Valves shall have stainless steel stems and spring loaded Teflon packing with replaceable seats and discs.

1. All modulating straight-through water valves shall be provided with equal-percentage contoured throttling plugs and shall be pressure independent type. All three-way valves shall be provided with linear throttling plugs such that the total flow through the valve shall remain constant regardless of the valve's position modulating. Valves shall be sized for a pressure drop equal to the coil they serve but not to exceed 5 psi. Valves shall have replaceable seats and discs. Pressure independent control valves shall be as manufactured by Griswold, Delta P, Warren Controls, Danfos, Bray, or approved equal.
2. Pressure Independent Actuated Ball Valves (PIC-V) for Flows up to 85 GPM

   a. The modulating control valves shall be pressure independent.
   b. Valves shall accurately control flow within +/-5% (including manufacturing tolerance) independent of system pressure fluctuation by maintaining a constant pressure differential across the control valve so that the valve only repositions on a change in load demand.
   c. The pressure independent modulating control valve shall include a Pressure Compensating Cartridge, Actuated Ball Valve, 2 PT’s, Manual Air Vent, Union, and Manual Isolation Ball in a single valve housing.

d. The valve shall have an accuracy of +/- 5% including manufacturing tolerances and pressure variations.

e. Valve housing shall consist of forged brass, rated at no less than 360 psi at 250°F.

f. A venturi flow meter fitting shall be field installed so that the flow rate can be read by means of differential pressure. Valve shall include a field installed venturi metering station so that the flow rate can be read by means of differential pressure. Venturi metering station shall not require any straight runs of piping before or after meter. Provide separate flow meter fitting if venturi flow meter is not integral to PIC valve assembly.

g. Both the ATC and shutoff valve shall have stems that are field repairable with the valve in the line. The body design shall allow inspection or repair of the stem without disturbing piping connections or draining water. The repairable stem shall include two Teflon seals and one EPDM O-ring for protection against chemicals and modulating temperature.

h. Valve shall have a union end connection with factory installed air vent to allow for venting of the coil or heat pump.

i. The control valve shall accurately control the flow from 0 to 100% full rated flow.

j. The ATC portion of the valve shall use the full 90 degrees of the stroke for control. Stroke limiting of the valve shall not be acceptable.

k. A flow tag shall be furnished with each valve.

l. A universal mounting plate shall allow installation of actuators meeting the system electrical requirements and valve torque requirements as provided by Honeywell, Invensys, Johnson Controls, KMC, Schneider, Neptronic, or Siemens.

m. The actuator and plate can be rotated after mounting.

n. The actuator mounting assembly shall accommodate no less than 1 ½” of insulation.

o. Pressure Compensating Cartridge (PCC)

    i. PCC shall automatically compensate for pressure changes in valve and shall maintain a constant pressure drop across the flow limiting actuated ball.

    ii. The operating pressure range shall be available with the minimum range requiring 3 PSID to actuate the cartridge and the maximum 8 psid to actuate the cartridge

    iii. Valve internal control mechanism includes a diaphragm and full travel linear coil spring.

    iv. Valves shall include an accessible/ replaceable cartridge.

    v. Dual pressure/temperature test valves for verifying the pressure differential across the cartridge and flow limiting ball shall be standard.

p. Actuated Ball Valve

    i. Valve ball shall consist of chemically plated nickel brass or stainless steel.

    ii. Actuator stem shall be removable/ replaceable without removing valve from line.

    iii. Manufacturer shall be able to provide ball insert to limit flow to maximum flow rate with ±5% accuracy. Insert shall be constructed of a Glass-Filled Polymer. The insert shall be press fit to the inside of the ball. Clipping the insert onto the exiting side of the ball shall not be acceptable.

iv. Each maximum flow rate selected shall use a different characterizing disc so that stroke limiting is not required.
v. Valve shall have a minimum rangeability as follows: ½”-40:1, ¾”-160:1, 1” to 3”-400:1
vi. Valve shall have EPDM O-rings behind Reinforced Teflon (PTFE) ball seals.
vii. The valve shall have a minimum close-off pressure differential rating of 100 psi with 35 in-lbs of torque for 1/2" to 2" sizes.
viii. Actuator shall provide minimum torque required for full valve shutoff position.

q. Isolation Ball Valve

i. Valve shall include a 600 WOG manual isolation ball valve.
ii. Stem shall be removable/replaceable with the valve in the line.

r. The control valve actuator will be furnished by the controls contractor under Section 230900.
s. Pressure independent valves shall come as one complete assembly from Griswold Controls or approved equal and shall include a supply side combination shutoff/ strainer valve.

3. MVP Pressure Independent Control Valves for Flows above 85 GPM.

a. Pressure Independent Flow Control Valve 2.5” and Larger

i. The modulating control valves shall be pressure independent.
ii. Valve shall accurately control flow within +/-5% (including manufacturing tolerance) independent of system pressure fluctuation by maintaining a constant pressure differential across the control valve so that the valve only repositions on a change in load demand.
iii. Contactor shall install pressure independent flow control valves where indicated in drawings.
iv. Valve shall be electronic, pressure independent, modulating 2-way control device.
v. Balancing valves shall not be required where pressure-independent valves are installed.
vi. Install venturi flow meter fitting to measure flow rate in gallons per minute.
vii. Valve shall include a venturi flow meter fitting so that the flow rate can be read by means of differential pressure. Venturi flow meter fitting shall not require any straight runs of piping before or after meter. Provide separate flow meter fitting if not integral to control valve.

b. Valve Actuator

i. Valve actuator housing shall be rated to IP44 insulation.

ii. Actuator shall be driven by a 24Vdc motor, and shall accept 2-10 Vdc, 4-20mA, 3-point floating or pulse width modulation electric signal and shall include resistor to facilitate any of these signals.

iii. Actuator shall be capable of providing 4-20mA or 2-10 Vdc feedback signal to the control system so that the gpm can be determined.

iv. External LED readout of current valve position and maximum valve position setting shall be standard.

v. Maximum flow setting shall be adjustable to 51 different settings within the range of the valve size by changing the settings electronically on the actuator.

vi. Optional fail safe system to power valve to either open or closed position from any position in case of power failure shall be provided per the sequence of operations and the automatic temperature control diagrams.

c. Valve Housing

i. 2.5"–6": Housing shall be constructed of Ductile Iron ASTM A536-65T, Class 60-45-18 rated at no less than 580 psi static pressure and 248°C.

d. Pressure Regulation Unit

i. Pressure regulation unit shall consist of 304 Stainless Steel and hydrogenated acrylonitrile butadiene rubber (1/2"–1-1/2") or 316 Stainless Steel and EPDM (2"–6").

ii. Flow regulation unit shall be accessible for maintenance without disturbing the piping.

iii. Valve shall have a maximum of 8.6 psid to actuate the pressure regulating cartridge.

iv. Dual pressure/temperature test valves for verifying accuracy of flow performance shall be available for all valve sizes.

4. Where applicable, all two (2) position control valves may be furnished with hose kits at Contractor's option. Coordinate actuator and pressure drop requirements with hose kit supplier. Maximum allowable pressure drop for two (2) position modulating control valves shall be 12 feet at scheduled flow rate.

5. Optional accessories shall include a stem packing lubricator for factory or field assembly. Valve stem packing shall be low friction, tight sealing Teflon.

6. Unitary valves shall be straight-through or three way type as specified in the sequence of operation with high-pressure connections suitable for copper pipe and rated for 250 psig. Stems shall be polished stainless-steel and packing shall be ethylene-propylene suitable for both chilled water and 250 degree hot water service. Straight-through valves shall have back-seating feature, to allow packing to be replaced without draining system.

7. All valves shall use guided valve plugs for good seating and reliable operation. Valves ½ inch to 1 inch shall be ANSI Class 125 brass body with screwed ends. Valves 1-1/4 inches to 2 inches shall be ANSI Class 150 brass body with screwed ends. Valves 2-1/2 inches to 4 inches shall be Class 125 cast iron body with bronze

trim and flanged ends. Valves 6 inches and larger shall be Class 125 steel body with bronze trim and flanged ends. Butterfly valves shall be DeZurick HIGH performance or Keystone Keylock, Lug style as specified in Division 23 Section, HVAC Piping, Fittings, and Valves.

8. All dual temperature coil control valves shall be normally open to the coil.

B. Control Valve Operators

1. Electric valve actuators shall be properly sized to provide sufficient torque to position valves throughout its operating range.
2. Use devices which are quiet in operation and which in the event of power failure, will "fail safe" by spring action in either the normally open or normally closed position as required for freeze, moisture, smoke, or fire protection. Spring return valves are required for all control valves where coils are exposed to outside air conditions.
3. Electric actuators requiring a 24VAC power supply will be utilized. Motors shall be specifically designed and sized with proper torque according to requirements of the device it is to be used on (i.e: valve, damper). Each actuator will accept the proper control input as the system is designed, (i.e.: floating, 0-10VDC, 4-10Ma etc.) without the need for any additional interface devices.

2.7. CONTROL PANELS

A. Furnish and install local panels for ATC devices. Control panels shall be fully enclosed cabinets, all steel construction and shall meet the requirements of NEMA 1 enclosures. Cabinet shall have piano hinged door with a locking latch. All cabinet locks shall use common key. Provide means of storing control system instructions and drawings inside cabinet for future reference. Panel shall be wall mounted or free standing and located where directed by the Contract Drawings or Engineer.

1. Each panel shall have all internal devices factory wired to a numbered terminal strip. Controllers and associated devices shall be mounted within the panel, accessible through a hinged door.
2. All ATC panels shall be provided with integral disconnect, wiring, and control transformers.
3. Any ATC control panel that is serving equipment on the emergency generator must be powered by an emergency generator fed circuit/electrical panel. Refer to electrical contract documents for all emergency powered equipment.

2.8. MISCELLANEOUS ELECTRICAL DEVICES

A. Electric Actuators. All automatically controlled devices, unless specified otherwise elsewhere, shall be provided with electric actuators which shall be sized to operate their appropriate loads with sufficient reserve power to provide smooth modulating action or two-position action and tight close off as specified.

B. Aquastats shall be line voltage strap on type with single pole, single throw switching. Switches shall have an adequate rating for the applied load. All wiring from aquastats to domestic recirculating pumps shall be by ATC contractor.

2.9. UNINTERRUPTIBLE POWER SUPPLY

A. Furnish, size and install uninterruptible power supplies (UPS's) at all ATC panels.

B. Provide all interlock and power wiring from U.P.S. to control panels as required such that all components are powered via the UPS. For hard-wired equipment furnished with pigtails/wire leads, e.g. control power transformers, splice pigtails/wire leads in junction box to a flexible cord with NEMA 5-15P Plug, which shall be plugged into the UPS.

C. UPS's shall be sized for the ATC panel load and shall provide at least 10 minutes of full load power in the event of a power outage.

D. UPS shall be furnished with plug and cord and shall be powered from power receptacle(s) in ATC panels.

2.10. DESKTOP WORKSTATIONS

A. Description: A tower or all-in-one computer designed for normal use at a single, semipermanent location.

B. Performance Requirements:

1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
2. Energy Star compliant.

C. Personal Computer:

1. Minimum Processor Speed: 3 gigahertz (GHz).
2. RAM:

   a. Capacity: 16GB.
   b. Speed and Type: 1333 MHz, SDRAM.

3. Hard Drive:

   a. Media: Solid state.
   b. Number of Hard Drives: One.
   c. Capacity: 250GB.

4. Optical Read and Write Drive:

   a. Include with at least 2 MB of data buffer.
   b. Type: SCS1 CD-ROM Drive with Read/Write Capability.
   c. Average access time of 150 ms or less.

5. At least four expansion slots.
6. Video Card:

   a. Resolution: 1920 by 1200 pixels.
   b. RAM: 4 GB.
   c. Controller Speed: 4GHz.

7. Sound Card:

    a. At least 128 voice wavetable synthesis.
    b. Capable of delivering three-dimensional sound effects.
    c. High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.

8. Two (2) Network Interface Cards: Include cards with connection, as applicable.

    a. 10-100-1000 base TX Ethernet with RJ45 connector port.
    b. 100 base FX Ethernet with SC or ST port.

D. Wireless Ethernet, 802.11 a/b/g/n.

1. Optical Modem: Full duplex link for connection to optical fiber cable provided.
2. I/O Ports:

    a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
    b. One serial port.
    c. One parallel port.
    d. Two PS/2 ports.
    e. One RJ-45.
    f. One stereo line-in and headphone/line-out on back panel.
    g. One microphone and headphone connector on front panel.
    h. One IEEE 1394 on front and back panel with PCI-e card.
    i. One ESATA port on back panel.

3. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

E. Keyboard:

1. 101 enhanced keyboard.
2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
3. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

F. Pointing Device:

1. Either a two- or three-button mouse.
2. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

G. Flat Panel Display Monitor:

1. Display:

    a. Color display with 21 inches diagonal viewable area.
    b. Digital input signal.
    c. Aspect Ratio: 16 to 9.
    d. Antiglare display.

e. Tilt adjustable base.
f. Energy Star compliant.
g. Resolution: 1920 by 1200 pixels at 60 Hz.
h. Number of Displays: One.

H. Speakers:

1. Two, with individual controls for volume, bass and treble.
2. Signal to Noise Ratio: At least 65 dB.
3. Power: At least 4 W per speaker/channel.
4. Magnetic shielding to prevent distortion on the video monitor.

I. I/O Cabling: Include applicable cabling to connect I/O devices.

2.11. CENTRAL CONTROL AND MONITORING SYSTEM (CCMS) (HARDWARE DESCRIPTION)

A. General

1. The Facilities Management Control System (FMCS) shall be comprised of a network of various independent, Stand-alone Digital Controllers (SDC'S), Mechanical System Digital Controllers (MSDC's), Air Handler Digital Controllers (AHDC's), Unitary Digital Controllers (UDC's); together with Centralized Control Stations (CCS), and Centralized Host Stations (CHS) as specified, to provide centralized access and facility wide control functions. The SDC's, MSDC's, AHDC's, UDC's shall be interconnected in a communicating network to provide facility wide access and sharing of information. A Gateway Digital Controller (GDC's) shall be provided to allow interface with third party microprocessor based control systems that are specified for integration within specification. A Local Area Network (LAN) shall be provided to interconnect SDC's for high-speed data transmission.
2. Specification Nomenclature

a.	FMCS	Facility Management Control System
b.	SDC	Stand-alone Digital Controller
c.	MSDC	Mechanical System Digital Controller
d.	AHDC	Air Handler Digital Controller
e.	UDC	Unitary Digital Controller
f.	HHOT	Hand Held Operator Terminal
g.	GDC	Gateway Digital Controller
h.	GP	Graphical Programmer
i.	CHS	Central Host Station
j.	CCS	Central Control Station
k.	RPTR	Communications Repeater

B. Centralized Host Stations (CHS)

1. The FMCS shall include Centralized Host Stations. CHS's shall, in conjunction with the full compliment of Digital Controllers, provide the performance requirements within this specification. Each CHS shall include all hardware and software components to serve as a centralized facility operator station, providing

color graphics, facility wide access, operator initiation of global control strategies, and centralized documentation.
The CHS shall be capable of simultaneously interfacing with the following:

a. -mouse pointing device
b. -two parallel printers
c. -high resolution VGA color graphics monitor
d. -seven auto answer/auto dial modems
e. -color inkjet printer
f. -two serial printers
g. -three FMCS LAN interface
h. -Alarm Graphic and Report FAX dial out service interface
i. -Mass storage tape system

As a minimum, the temperature control contractor shall provide the types and quantities of CHS, CCS, SDC, MSDC, AHDC, GDC, and UDC as required.

2. Computer

a. The new FMS computer shall be located in the School Board's Central Maintenance Office shall be utilized with the new CCMS System. Provide modem terminal, and wiring as required to interface this school's CCMS system with FMS computer. I/P data drop shall be provided adjacent to the network panels.
b. Coordinate IP address with Owners' I.T. Department for network connection. The CCMS must be fully networkable.
c. Provide fiber optic cable as required.
d. Extend Existing Building Management System (BMS) as required to accommodate all equipment on this project.

3. Operator Workstation: One PC-based microcomputer with minimum configuration as follows:

a. Uninterruptible Power Supply: 2 kVa.
b. Operating System: Microsoft Windows – Latest Version.

i. ASHRAE 135 Compliance: Workstation shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
ii. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.

C. Centralized Control Stations (CCS)

1. The FMCS shall include Centralized Control Stations, as required. CCS's shall, in conjunction with the network of SDC's and additional CCS components as required, provide the performance requirements within this section of the specification. Each CCS shall include all hardware and software components to serve as a centralized facility operator station, providing facility wide access, for review and modification of global control strategies, real time system monitoring, controller database editing or creation, and centralized documentation.

D. Local Area Networks

1. The LAN shall utilize packetized transmissions, CRC 16 error checking, and distributed error recovery. Single or multiple SDC failures shall not cause loss of communication between other LAN-connected SDC's.
2. LAN connected SDC's shall be provided with a communications watchdog to assure that an individual SDC cannot permanently occupy the LAN. If an SDC is determined to be monopolizing communications, it shall be automatically shut down and an exception reported to annunciate this fact.
3. The LAN shall employ a token passing, peer-to-peer convention, same as or similar to the industry standard format IEEE 802.4. The content of messages shall be the manufacturer's standard. The Local Area Network components shall be manufacturer's standard or available from third party vendors which utilize the same chip implementation as used by the manufacturer.
4. Industry standard ANSI, RS-485 Network Communication System, Lon, or Bacnet, or Equivalent shall be utilized.
5. Trunk Wiring Practices - General

a. The distributed communication network system shall consist of a multi-drop RS-485 bus architecture connecting SDC's, MSDC's, AHDC's, GDC's, and UDC's. The trunk shall consist of:

i. A twisted pair of wires (24 awg) completely encased in continuous metallic conduit.
ii. A twisted shielded pair of wires (24awg) with the shield grounded in accordance with the manufacturer's wiring practices.
iii. Or a dual channel, 62.5 micron fiber cabling system with ST type connectors.

There shall be no power wiring, in excess of 30 VAC rms voltage, run in conduit with communications trunk wiring. In cases where power or signal wiring is run in conduit with trunk wiring, all communications trunk wiring and power wiring shall be run using separate twisted shielded pairs (24awg) with the shields grounded in accordance with the manufacturer's wiring practices.

b. Communication Transient Protection

i. The manufacturer's catalog data sheet shall provide evidence that all FMCS products offered by the manufacturer are tested and comply with the standard for Transient Surge withstand capabilities for electrical devices ANSI C62.41, IEEE-587-1980, Categories A and B. Such testing shall have included power and communication trunk wiring. Compliance with IEEE-587 shall imply conformance with IEEE-472 transient standards based on the stated position of ANSI and IEEE regarding applicability of the rated standards.
ii. In addition, at each building entry and exit point, the wire communications trunk wiring shall be protected with a transient surge protection device providing the minimal protection specifications of the General semiconductor, Model #422E device. Transient surge protection is not necessary if the

communication trunk, external to the building, is fiber optic in nature.

iii. The communications circuitry and input/output circuitry, of the SDC's, MSDC's, and AHDC's, shall provide protection against a 1000 volt, 3 amp transient signal, directly applied to the communication or input/output terminations. The manufacturer's catalog data sheet shall provide evidence of conformance with this requirement. Systems not complying with this requirement shall provide equivalent protection external to the FMCS controller. Protection shall be provided for the individual communications and input/output terminations for each FMCS controller. Submittal documentation shall clearly define how this requirement will be met and how the external protection will not affect the performance of the controllers.

c. RS-485 Trunk Distance and Topology

The manufacturer's RS-485 trunk shall provide operation over end to end linear distances of 4000 feet for wire connections and 6,500 feet for fiber optic connections, without repeaters, at communication data rates of up to 64 kbps. The trunk may be extended up to 20,000 feet through the use of wire repeaters or 80,000 feet through the use of fiber optic repeaters.

At data rates of up to 19.2 kbps, the trunk distance shall be extendible to distances of up to 20,000 feet using RS-485 communication wire or fiber optic repeaters. A repeater shall be used each 4,000 feet of linear distance for wire or every 6,500 feet for fiber optics. Repeating devices shall contain separate LED indication for each communication interface trunk to indicate proper operation of the repeater as well as the communications trunks.

Contractors shall provide devices which are of FMCS control system manufacturer's design.

d. It shall be possible for the trunk to be "T" eed or "starred", at any location using a repeater, to facilitate the installation. Systems which do not provide this capability shall provide a trunk riser diagram showing end to end distances and locations of system topology necessary to meet the trunk diagram shown on the plans.

e. Fiber Optic Communication Trunk

The temperature control contractor shall provide a dual channel fiber optic data link, as required, to minimize the effects of transient surges caused by lightning or external EMI generating equipment. The data link shall be comprised of a single duplex cable containing two fibers (transmit and receive), of 62.5 micron construction, to accommodate data rates of up to 64 kbps.

The fiber optic trunk shall be connected to SDC devices using manufacturer's standard RS-485 to fiber optic data link modem. Repeating devices shall contain separate LED indication for each communication interface and the fiber modem, to indicate proper operation of all aspects of the device. Fiber modem devices shall be tested and conform with transient surge withstand tests for electrical devices, ANSI C62.41 IEEE-587 Categories A and B. Manufacturer's data sheet shall provide evidence of compliance with this requirement. Manufacturer's products which do not meet this minimum performance requirement shall not be acceptable.

Systems which require a special gateway controller to accommodate the fiber optic trunks, shall provide such a controller per point where the fiber optic cable enters and leaves the building. Gateway controllers shall not inhibit transfer of point data values between SDC controllers throughout the LAN. Such inhibitive systems shall not be acceptable.

In lieu of the above two options, the contractor may provide a fiber optic link to each SDC controller within the LAN. All controllers shall have access to the fiber optic link for LAN.

Fiber optic cable shall be fully tested and terminated by the temperature control contractor.

E. Standalone Digital Controllers (SDC)

1. General

Standalone Digital Controllers (SDC) shall be 16 bit microcomputer based, utilizing a multi-tasking, multi-user operating system.

The SDC controllers shall permit the simultaneous operation of all control, communication facilities management and operator interface software, as programmed by the Contractor or User. Modification of the on-board SDC controller database shall be performed on-line using the built-in or HHOT interface. Systems which require the SDC to be removed from service while DDC control sequences are modified shall not be acceptable.

SDC controllers shall utilize true floating point arithmetic capabilities. To accommodate totalization of large totalized values, SDC's with reporting capability shall support the calculation, accumulation and display of values within the range of +/-10 to the 10th power.

2. Database and Memory Back-up

All programming defining the functions to be performed by the SDC, including but not limited to application programs and point database within each SDC, shall be protected from loss due to power failure for a minimum of six months. Systems providing non-volatile memory for these functions are preferred. Systems not providing non-volatile memory shall provide a system rechargeable battery backup system sufficient to provide protection for the specified 6 month period. Systems not in compliance shall provide for uninterrupted power to each SDC.

3. Service Ports

SDC controllers shall be equipped with a minimum of one operator service port for the connection of a HHOT. The service port shall be either a built-in RS-232 data terminal port or an RJ-11 type jack which connects to the manufacturer's standard HHOT.

Connection of a service device, to a service port, shall not cause the SDC controller to lose communications with its peers or other networked device controllers.

The service port shall allow utilization of the same HHOT from any location. The same HHOT shall be utilized for any SDC, MSDC, AHDC, or UDC Systems which utilize more than one variety of HHOT shall not be acceptable.

4. Display and Readout Capability

The SDC controller shall provide manufacturer’s standard display and readout capability.

5. Manual/Auto Control and Notification

The SDC controller shall provide commanded override capability from the HHOT or the built-in operator interface. Such overrides shall be annunciated to the CHS's. Such overrides shall be valid as long as power is applied to the controller.

Manual service overrides, such as Hand/Off/Auto switches, shall be provided as indicated on the drawings. Such overrides shall be located at the controlled device location and conform with OSHA Manual lockout regulations, as appropriate, for safety reasons. SDC indication of such manual override actions shall be provided as feedback status indication points shown on the drawings, in conjunction with the application programs within the SDC. Systems which provide built-in H/O/A switching devices with integral feedback shall provide external manual service overrides, as indicated, to comply with OSHA manual lockout regulations. H/O/A switches remotely located at the SDC controller are not acceptable.

6. Adjustments

Every control panel shall provide adjustments for the functions specified. In general, adjustments shall be provided for all set points used by controllers within each control panel. In addition, adjustments shall be provided for throttling ranges, mixed air damper minimum positions, or other items as specified. Adjustments shall be integral to each individual SDC. The built-in operator interfaces shall allow the easy execution of the adjustment through named identifiers within the SDC. From a single SDC user interface, any other SDC shall be accessible and full adjustment capabilities shall be provided.

7. Sensing and Control Outputs Requirements

a. Sensing

i. All sensing inputs shall be provided via industry standard signals. Temperatures, humidities, differential pressure signals, and other signal inputs shall be one of the following types:

1) 0-20 mA
1) 4-20 mA
1) 0-5 VDC
1) 0-12 VDC

ii. 1000 ohm platinum (at O°C, 2.62 ohms/°C)
iii. 1000 ohm Balco (2.2 ohms/°F)
iv. 10 k ohm Thermistor (at 25°C/77°F)

Custom, definable input signals (accept sensor inputs from RTD devices, other than those of the manufacturer).

All signal inputs shall be compatible with the controllers used, and with the requirements for readout of variables in true scaled engineering units as specified.

b. Control Outputs

i. On/Off Outputs

Control panel shall internally provide test points for the circuit driving the equipment contactor, for the purpose of troubleshooting the 120 VAC or 240 VAC circuit to the contactor. All such relays or digital output modules shall provide a pilot light or LED display of the same status. On/Off output modules shall be of the modular construction that can be easily and quickly replaced, on an individual basis, if the module were to be damaged.

ii. Modulating Outputs

Modulating outputs shall be industry standard 0-5 VDC, or 0-12 VDC with definable output spans, to adapt to industry available control products. Milliamp outputs of 0-20 mA or 4-20 mA are also acceptable. Drive open/Drive closed type modulating outputs are acceptable provided that they also comply with the following requirements.

All modulating outputs shall provide within the control panel, a meter gauge, or display indication via on board display or HHOT, the commanded position signal for the actuating device. This meter, gauge, or display must provide either a 0-100 percent position indication, or read out directly in the engineering unit of the signal being used. Drive open/Drive closed type controllers shall include sufficient components and control algorithms to comply with this requirement. In the case of Drive open/closed technology, position feedback shall be provided to insure positive indication that the control device is at the commanded position.

F. Mechanical System Digital Controllers (Msdc's)

1. General

a. Controls shall be microprocessor based, Mechanical System Direct Digital Controllers (MSDC's). MSDC's shall be provided for air handling units, central pump systems and other applications as required. MSDC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the MSDC. The application control program shall be resident within the same enclosure as the input/output circuitry which translates sensor signals. All input/output signal conversion shall be performed through a minimum of a 12 Bit A to D converter. All input/output points shall be universal in nature allowing their individual function definition to be assigned through the application software. All unused input/output points must be available as universally definable at the owner discretion. If input/output points are not fully universal in nature, unused points must be equal in quantity between Analog Input, Digital Input, Analog Output, Digital Output.

Contractor shall provide a minimum of one MSDC controller per mechanical system, as shown on the drawings.

The BAS contractor shall provide and field install al MSDC's specified under this section. Mechanical Equipment manufacturers desiring to provide MSDC type controls as factory mounted equipment, shall provide a separate bid for their product less all controls, BAS/Temperature Control Contractor.

b. All input/output signals shall be directly hardwired to the MSDC. Trouble shooting of input/output signals shall be easily executed with a volt-ohm-milli-amp meter (VOMA). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be used.

c. MSDC shall be in continuous direct communication with the network which forms the facility-wide Building Automation System (BAS). The MSDC's shall communicate with the SDC at a baud rate of not less than 19,200 baud.

2. Non-Volatile Memory

a. All control sequences programmed into the MSDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained. Power failures shall not cause the MSDC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The MSDC shall allow for the creation of unique application control strategies. Systems that allow selection of sequences from the library or table are not acceptable.

b. All control sequences shall be fully field programmable at the MSDC controller, allowing for the creation or editing of an application sequence of operations.

c. Each MSDC shall be provided with manufacturer's standard built-in Operator Interface.

d. The MSDC shall allow for internal processing and reporting of user defined Time of Day Schedules, Alarms, Trend Reports, Run Time Totalization, Energy Utilization Reports, Application Program Documentation and interface with a peripheral device such as an autodial/autoanswer modem, a VT-100 Display Terminal, or a serial printer.

    i. Systems not providing the above functionality at the MSDC are not acceptable and shall utilize an SDC in place of the MSDC.

e. The MSDC shall provide LED indication of transmit/receive communications performance as well as for the proper/improper operation of the controller itself.

f. The MSDC shall be provided with a battery backed time clock that is capable of maintaining the time of day and calendar for up to thirty days without loss of setting. The battery for the time clock shall be field replaceable by the customer. Integral daily, weekly, holiday and special event scheduling shall be provided, such that all schedules can be custom tailored to the facility. Predefined schedules, with set quantities of on/off cycles are not acceptable.

3. Controller Location

a. To simplify controls, mechanical service and troubleshooting, the MSDC shall be mounted directly in or on the control compartment of the mechanical system. The MSDC shall be provided in a NEMA 1 enclosure to accommodate direct mounting on the equipment to be controlled. The MSDC shall be constructed in a modular orientation such that service of the failed components can be performed quickly and easily. The modular construction should limit the quantities of printed circuit boards to a maximum of three. When required to replace a printed circuit board, it shall not be necessary to disconnect any field wiring. The MSDC shall allow for the creation of, unique, application control strategies. Systems that allow selection of sequences from a library or table are not acceptable. This shall allow all controls maintenance and troubleshooting to be made while at the unit location. MSDC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.

b. For compatibility to the environment of the mechanical systems, MSDC shall have wide ambient ratings. MSDC shall be rated for service from -

40 Deg F (Degrees Fahrenheit) to 140 Deg F.

c. Contractor shall submit description of location for the MSDC's on all mechanical equipment.

G. Air Handler Digital Controller (AHDC)

1. General

a. Controls shall be microprocessor based, Air Handler Digital Controllers (AHDC's). AHDC's shall be provided for air handling units, kitchen vent units, rooftop units energy recovery ventilators, make-up air units, and other applications as required. AHDC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the AHDC. The application control program shall be resident within the same enclosure as the input/output circuitry which translates the sensor signals. All input/output signal conversion shall be performed through a minimum of a 10 bit A to D converter. All input points shall be universal in nature allowing their individual function definition to be assigned through the application software. All unused input points must be available as universally definable at the discretion of the owner. If the input points are not fully universal in nature, unused points must be equal in quantity between Analog Inputs and Digital Inputs. Contractor shall provide a minimum of one AHDC controller per air handling system as shown on the drawings.

The BAS contractor shall provide and field install all AHDC's specified under this section. Mechanical equipment manufacturers desiring to provide AHDC type controls as factory mounted equipment, shall provide a separate bid for their products less all controls, actuators, valve assemblies and sensors, which are specified to be provided by the BAS/Temperature control contractor.

b. All input/output signals shall be directly hardwired to the AHDC. Troubleshooting of input/output signals shall be easily executed with a volt-ohm meter (VOM). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be utilized.

c. AHDC's shall be in continuous direct communication with the network which forms the facility wide Building Automation System. The AHDC's shall communicate with the SDC at a baud rate of not less than 19,200 baud.

2. Non-Volatile Memory

a. All control sequences programmed into the AHDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the AHDC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The AHDC shall allow for the creation of unique application control sequences. Systems that only allow selection of sequences from a library or table, are not acceptable.

b. All control sequences shall be fully programmable at the AHDC, allowing for the creation and editing of an application control sequence, while at the unit.

c. The AHDC shall be provided with an interface port for the HHOT. The interface port shall allow the HHOT to have full functionality as described. From the interface port, the HHOT shall be able to directly access any AHDC, or UDC in the network.

d. The AHDC shall provide an input/output point trending utility that is capable of accumulating 48 analog point samples and 10 digital point samples, per Input/Output point. Each sample shall be taken on a user defined interval, ranging from 1 second to 255 hours per sample. The digital readings shall be on a change of state occurrence for the digital points. All samples shall be recorded with the engineering units for the value, along with a time and date identifier for each sample taken. The samples shall be protected against loss due to power interruptions through a battery or capacitor backup method for a minimum of 30 days.
Systems unable to provide the above capability shall provide for the individual Input/Output point trending at the SDC. Specifics as to how each AHDC point will be trended, at the SDC, shall be provided in the submittal documents. Included in the explanation shall be the sample intervals, the memory allocation in the SDC and the number of AHDC's per SDC that can be expected.

e. The AHDC shall provide LED indication of transmit/receive communications performance, as well as for the proper/improper operation of the controller itself.

f. The AHDC shall be provided with a battery backed time clock that is capable of maintaining the time of day and calendar for up to thirty days, upon loss of power to the AHDC, without loss of setting. The battery for the time clock shall be replaceable by the customer. The AHDC shall be provided with integral time schedules; as a minimum, two seven day schedules with eight on/off periods per day shall be provided. Holiday override of weekly schedules shall be provided for pre-scheduling of holidays, for the year in advance.

3. Controller Location

a. To simplify controls and mechanical service troubleshooting, the AHDC shall be mounted directly in or on the controls compartment of the air handling system. The AHDC shall be provided in a NEMA 1 enclosure to accommodate direct mounting on the equipment to be controlled. The AHDC shall be constructed in a modular orientation such that service of the failed components can be done quickly and easily. The modular construction should limit the quantities of printed circuit boards to a maximum of two. All logic, control system, power supply and input/output circuitry shall be contained on a single plug-in circuit board. When required to replace a printed circuit board, it shall not be necessary to disconnect any field wiring. This shall allow all controls maintenance and troubleshooting to be made while at the air handling unit. The AHDC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.

b. For compatibility to the environment of the air handling unit, AHDC's shall have wide ambient ratings. AHDC's shall be rated for service from -40 Deg F (Degrees Fahrenheit) to 140 Deg F.

c. Contractor shall submit description of location of AHDC's on all mechanical and air handling equipment.

H. Unitary Digital Controller (UDC)

1. General

a. Controls shall be microprocessor based Unitary Digital Controllers (UDC's). UDC's shall be provided for equipment as necessary. UDC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the UDC. The application control program shall be resident within the same enclosure as the input/output circuitry which translates the sensor signals. All input/output signal conversion shall be performed through a minimum of a 10 bit A to D converter.
Contractor shall provide a minimum of one UDC controller per unitary system as required.
The BAS contractor shall provide and install all UDC's specified under this section. Mechanical equipment manufacturers desiring to provide UDC type controls as factory mounted equipment, shall provide a separate bid for their products less all controls, actuators, valve assemblies and sensors, which are specified to be provided by the BAS/Temperature control contractor.

b. All input/output signals shall be directly hardwired to the UDC. Troubleshooting of input/output signals shall be easily executed with a volt-ohm-milli-amp meter (VOMA). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be utilized.

c. UDC's shall be in continuous, direct communication with the network which forms the facility wide building automation system. The UDC's shall communicate with the SDC at a baud rate of not less than 9,600 baud.

2. Non-Volatile Memory

a. All control sequences programmed into the UDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the UDC memory to be lost, nor shall there be any need for batteries to be recharge or replaced to maintain the integrity of the controller database. The UDC shall allow for the creation of unique application control sequences. Systems that allow only selection of sequences from a library or table are not acceptable.

b. All control sequences shall be fully configurable at the AHDC, allowing for the creation and change of a sequence while at the unit.

c. The UDC shall be provided with the ability to interface with the HHOT. The interface port shall be provided at the wall sensor or within the unitary equipment, as specified on the plans. The interface port shall allow the HHOT to have full functionality as described hereinbefore of this specification. From the interface port, the HHOT shall be able to directly access any AHDC or UDC in the network.

d. The UDC shall provide an input/output point trending utility that is capable of accumulating 48 analog point samples and 10 digital point samples per Input/Output point. Each sample shall be taken on a user defined interval, ranging from 1 second to 255 hours per sample. The digital readings shall be on a change of state occurrence for the digital points. All samples shall be recorded with the engineering units for the value, along with a time and date identifier for each sample taken.

Systems unable to provide the above capability shall provide for the individual input/output point trending at the SDC. Specifics as to how each UDC point will be trended, at the SDC, shall be provided in the submittal documents. Included in the explanation shall be the sample intervals, the memory allocation in the SDC and the number of UDC's per SDC that can be expected.

e. The UDC shall provide LED indication of transmit/receive communication performance, as well as for the proper/improper operation of the controller itself.

3. Controller Location

a. To simplify controls and mechanical service troubleshooting, the UDC shall be mounted directly in the controls compartment of the unitary system. The UDC shall be provided with a sheet metal or polymeric enclosure that is constructed of material allowing for the direct mounting within the primary air stream, as defined by UL-465. The direct mounting shall allow all controls maintenance and troubleshooting to be made while at the unitary equipment. The UDC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.

b. For compatibility to the environment of the unitary equipment, UDC's shall have wide ambient ratings. UDC's shall be rated for service from 32 Deg F (Degrees Fahrenheit) to 140 Deg F.

c. Contractor shall submit description of location of UDC's on all mechanical and unitary equipment.

I. Gateway Digital Controller (GDC)

1. General

a. Controls shall be microprocessor based, Gateway Digital Controllers (GDC's). GDC's shall be provided for the purpose of integrating microprocessor based, communicating, direct digital control systems from vendors other than the primary, selected controls manufacturer. GDC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the GDC. All communications interface control programs shall be resident within the GDC.

The BAS contractor shall provide and field install all GDC's specified under this section. Any interface requirement beyond a two wire communications wire link, shall be provided by the equipment manufacturer supplying the non-primary or third party microprocessor based, communicating, direct digital controllers.

b. All GDC's shall exist at the LAN level with the SDC's. The GDC's shall possess all capabilities described under the SDC section while additionally providing the interface to the third party systems described above. The

GDC's shall communicate with the third party controllers at the highest possible baud rate offered by the third party system. As a minimum, 9,600 baud communications shall be utilized.

c. All control sequences programmed into the GDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the GDC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The GDC shall allow the standard database information from the third party system to be integrated in standard FMCS data formats, allowing for the creation of unique application control sequences. Systems that only allow selection of data and sequences from a library or table, are not acceptable.

d. Each GDC shall be provided with manufacturer's standard built-in operator interface.

The GDC shall provide Alarming, point trending and Energy report generation capabilities. Alarming points shall be uniquely definable, with multiple alarms assignable to a single point. Such alarm shall be provided with a unique 80 character message. Systems utilizing an alarm message library, shall describe the size of the library and verify how all alarming within the GDC will be guaranteed unique 80 character messages.

The quantities of trended point values shall be limited only by total controller memory space. If necessary, a GDC may be dedicated fully to a trending task, allowing all controller memory to be available for the trend storage. Each unique trend report shall contain a minimum of 4 different points and a minimum of 128 samples per point. Trending frequency for each report shall be operator definable from a sample once a second to a sample once every 24 hours. Trend reports shall be internally formatted by the GDC and shall be reportable directly to a serial printer, a VT-100 display terminal, a CCS, CHS or any other device capable of receiving a formatted ASCII data file.

e. The energy reports shall not be limited in quantities only by available memory within the GDC. Each Energy Report shall be fully formatted and reportable to a serial printer, a VT-100 display terminal, a CCS, a CHS or any other device capable of receiving a formatted ASCII data file. As a minimum, each Energy Report shall provide a daily report and a monthly report with summary information such as outside air temperature, outside air humidity, total energy consumed and degree day calculations.

f. The GDC shall be provided with a battery backed clock that is capable of maintaining the time of day and calendar for up to thirty days, upon loss of power to the GDC, without loss of setting. The battery for the time clock shall be field replaceable by the customer.

2.12. HEAT PUMP CONTROLLER

A. All heat pump controls shall be provided by the ATC subcontractor. Heat pump controls furnished by the equipment manufacturer and integrated into the building automatic system are not acceptable. The use of unitary controllers for heat pumps is not acceptable. Heat pump controllers shall be fully programmable with sufficient memory and spare point capacity to accommodate expansion in the future.

1. Heat pump controllers for the listed manufacturers subject to compliance with

requirements shall be as follows:

2. Pritchet Controls – Reliable Controls.
3. Johnson Control – DX9100.
4. Siemens – PXC22 or UC 14/10
5. Automated Logic – SE Line Controller
6. Alerton – VLC853.
7. Honeywell – Excel 50.
8. Trane

2.13. SYSTEM SOFTWARE DESCRIPTION

A. General

1. Contractor shall provide all software for a complete and operational system as described herein. Software shall include manufacturer's standard multi-tasking, multi-user operating system for operator consoles and controllers, network communication software for dial-up and hard trunk applications, operator man-machine interface software, control application software and all other software necessary to provide the functions specified herein.
2. System software shall be as manufactured by Siebe Environmental Controls, Johnson Controls, Johnson Controls Facility Explorer, Honeywell, Siemens, Alerton, Reliable Controls, Schneider Electric, Advanced Power, Trane, or approved equal.

2.14. EXCEPTION REPORTING SEQUENCES

A. Alarm/COS Reports

1. For those digital points indicated on the drawings, the Contractor shall provide a unique change-of-state alarm message of up to 70 characters. The message shall report to all devices assigned to the alarm class.
2. For those points indicated on the drawings which are designated as interrupt priority, the Contractor shall provide an interrupting process display at the CHS location which displays the current conditions for the operator.
   In addition, the CHS computer shall automatically send a picture of the process graphic display to the remote locations via e-mail.
3. For those points designated in paragraph 3 above, the FMCS shall also send a history log to the system report printer of the immediate prior history of the points causing the interrupt priority. This log shall contain 1 minute samples of the previous 15 minutes of operation.
4. For those points on the drawings designed as Hard Facts points, the Contractor shall provide an alarm message to a remote facsimile location designated by the Owner. The FMCS system shall provide at the remote location, a facsimile print-out showing location, time/date of alarm and alarm message of the point. For interrupt priority fax alarms, the remote facsimile machine shall receive a hard copy of the interrupt process screen showing on-line dynamic data values of the current conditions.

B. Off Hours Exception Reporting

1. The Owner shall specify up to five sites to which off hours exceptions shall be

auto-dialed and reported. This shall allow the owner to assign off hours exception responses to various facility personnel as necessary. Selection of the site to be dialed can be programmed by the Owner, and set to change automatically per time of day and day of week.

2.15. MONITORING SYSTEM, SENSORS AND WIRING

A. Sensors and other Devices for Input/Output Summary Schedule:

1. Provide all necessary sensors, relays, panels, conduits and wire for the points indicated in the input/output summary as shown on the contract drawings.
2. Analog sensing elements for remote indication shall be independent of local sensors used for local control loops.
3. Temperature sensors shall be Resistance Temperature Detector (RTD) type of 1000 ohm balco. Space (60-90 degrees F); Duct/Well (-30-250 degrees F); Averaging Duct (-30-225 degrees F) or as required under Division 26.

   a. Space temperature sensors shall be provided with blank commercial type locking satin chrome covers.
   b. Duct temperature sensors shall be rigid stem or averaging type as specified in the sequence of operation. Water sensors shall be provided with a separable copper, monel or stainless steel well. Outside air wall mounted sensors shall be provided with a sun shield.
   c. The dew point sensor shall employ a non-reactive organic bobbin material to give precise dew point readings with accuracy of not more than + 1.5 degrees F. The dew point sensor shall incorporate an integral draft shield as part of the instrument for air velocities in excess of 50 feet per minute. The dew point sensor shall operate over a minimum dew point temperature range suitable to application.

4. Relative humidity sensors shall be capacitance type with 10 percent to 90 percent range. Duct mounted relative humidity sensors shall be provided with a sampling chamber. Wall mounted sensors shall be provided with covers identical to temperature sensors. Space 10 percent -90 percent RH; Duct 10 percent - 90 percent RH.
5. All wall mounted temperature sensors, relative humidity sensors, and CO2 sensors shall be installed with stainless steel wire guard. Set point adjustment shall be achievable without removing the wire guard.
6. Differential and Static Pressure Sensors and Switches

   a. Fan proof-of-flow switches shall be U.L. listed adjustable set point and differential pressure type. Switches shall be piped to fan discharge except where fans operate at less than one inch WG, they shall be piped across the fan. For fractional horsepower and non-ducted fans, relays or auxiliary contacts may be used. Maximum pressure rating shall be at least 10 inches WG. with .05-12 inch W.C. range.
   b. Pump proof-of-flow switches shall be U.L. listed adjustable differential pressure or flow type as specified in the sequence of operation or data point summary. Devices shall be 150 psi rated except chilled water flow switches shall be provided with totally sealed vapor tight switch enclosure on 300 psi body. Differential pressure switches shall have valved

manifold for servicing, and a range of 3 psi-150 psi.

c. Air flow and static pressure analog sensors shall be high accuracy suitable for the low velocity pressures to be encountered, be selected for approximately 50 percent overrange, and have a 4 to 20 ma output. These differential pressure sensors shall be connected to the air flow measuring station with valved lines for testing and calibration, and shall have adjustments for zero and span. 5 inch W.C. range.

d. Water flow analog sensors shall be provided complete with flow element and shall be an all solid state precision industrial type with stainless steel meter body, maximum error of no more than .5 percent or span, and 4 to 20 ma output. Sensor shall be rated for 250 psi minimum and installed in strict accordance to the manufacturer's instructions complete with three-valve manifold for calibration and maintenance.

7. Overall system accuracy, including electronic analog sensing elements, shall be as follows:

   a. Air: Plus or minus 1.0 degrees F temperature, plus or minus 2.5 percent r.h., plus or minus 2.0 percent static pressure.
   b. Water: Plus or minus 0.7 degrees F over full scale range for water points, plus or minus 1.0 degree F for others.
   c. Proof of fan or pumps operating status, or alarm conditions shall be through positive feedback from differential pressure switches across fan or pump. Auxiliary dry contacts may be used for proof of fans or pumps if the motors are fractional H.P., and other non-ducted fans.

8. Digital inputs from devices with isolated, dry type contacts (no grounds, no voltage) of either normally open (N.O.) or normally closed (N.C.) configuration shall be provided. Live contact inputs, those that have voltage present, shall be provided with isolating devices to meet dry contact requirements.
9. Liquid flow data shall be received and transmitted by commercial grade instrument similar in quality to Honeywell 411, Rosemount, Foxboro, MAMAC Systems or approved equal, type differential pressure transmitter. Pulse type data sensors shall not be acceptable. Speed response of differential pressure transmitters shall be at least 500 milliseconds. Maximum error signal shall be +/- 1 foot.
10. Start-stop relay module shall contain relays for start-stop function at the remote point, with relays mounted and factory wired to numbered terminal strips.
11. Outage Devices:

   a. Control Relays: Control relay contacts shall be rated for the application, with a minimum of two sets of Form C contacts, enclosed in a dustproof enclosure. Relays shall have silver-cadmium contacts with a minimum life-span rating of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression limiting transients to nondamaging levels.
   b. Time Delay Relays: Time delay relay contacts shall be rated for the application with a minimum of two sets of Form C contacts enclosed in a dustproof enclosure. Relays shall have silver-cadmium contacts with a minimum life span rating of one million operations. Relays shall be equipped with coil transient suppression devices to limit transients to

nondamaging levels. Delays contact opening or closing shall be adjustable from one to 60 seconds with a minimum accuracy of plus or minus 2 percent of setting.

c. Latching Relays: Latching relay contacts shall be rated for the application with a minimum of two sets of Form C contacts enclosed in a dustproof enclosure. Relays shall have silver-cadmium contacts with a minimum life-span rating of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to nondamaging levels.

d. Reed Relays: Reed relays shall be encapsulated in a glass-type container housed in a plastic or epoxy case. Contacts shall be rated for the application. Operating and release times shall be one millisecond or less. Reed relays shall have a minimum life span rating of 10 million operations.

e. Contactors: Contactors shall be of the single-coil, electrically operated, mechanically held type. Positive locking shall be obtained without the use of hooks, latches, or semi-permanent magnets. Contacts shall be double-break silver-to-silver type protected by arcing contacts. Number of contacts and ratings shall be selected for the application. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices to limit transients to nondamaging levels.

f. Solid-State Relays: Input-output isolation shall be greater than 1000 megohms with a breakdown voltage of 1500 V rms or greater at 60 Hz. The contact life shall be 10 million operations or greater. The ambient temperature range shall be minus 20 degrees to plus 140 degrees F. Input impedance shall not be less than 500 ohms. Relays shall be rated for the application. Operating and release times shall be one millisecond or less. Transient suppression shall be provided as an integral part of the relay to limit transients to nondamaging levels.

12. Audible Alarm:

a. All alarms shall annunciate on the ATC system front end computer and via pagers.

2.16. MAKE-UP WATER FLOW METER/ALARM

A. In-line T-mounted Flowmeter: Made for installation between pipe flanges; measures flow directly in gallons per minute. As manufactured by Aaliant, Badger, Hersey, Kele, Data Industrial or approved equal.

1. Construction: Stainless steel body, with integral transmitter and direct - reading scale.
2. Pressure rating: 400 psig maximum.
3. Temperature Rating: 221 F maximum
4. Display: Two lines; alphanumeric characteristic each. Visual instantaneous rate of flow, with register to indicate total volume in gallons.
5. Output: Two simultaneous outputs; 4 to 20 mA, two-wire, pulse.
6. Transmitter: Universal flow transmitter with pulse output (totalization) to convert digital pulses to totalized gallons.

7. Electronic Housing: NEMA4, 3/4 NPT conduit connection, epoxy coated aluminum.
8. Accuracy: Plus or minus 1 percent of reading.
9. Key Pad: Setting of recalibration, engineering units, data logging sample time, alarms, response time.

B. Power and control wiring to be furnished and installed under this Section of Division 23.

2.17. FLOW MEASURING STATIONS

A. Furnish and install an Onicon Model F-1210, Hersey, Kobold or approved equal dual turbine insertion flow sensor complete with hot tap full port ball valve and installation hardware. The dual turbine element shall have counter rotating axial turbine elements, each with its own rotational sensing system, and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion. Paddle type rotors will not be acceptable. Rotational sensing of each turbine shall be accomplished electronically by sensing impedance change and not with magnetic or photo-electric means. Each sensor shall be individually calibrated and tagged accordingly against the manufacturers primary standards which must be accurate to within 0.1 percent and traceable to the U.S. National Institute of Standards and Technology (NIST).

B. The sensor shall have a maximum operating pressure of 400 PSI, maximum operating temperature of 220 degrees F (optional 300 degrees F) and a pressure drop of less than 1 PSI at 17 feet per second flow rate. Flow sensor shall have 100:1 turndown ratio. Accuracy shall be + 2 percent of actual reading from 0.4 feet per second to 20.0 feet per second.

C. The sensor shall have integral analog outputs of 0-10 VDC and 4-20 mA current output for connection to the Central Control System. The sensor shall also include three integral frequency outputs, (top turbine, bottom turbine, average frequency) for diagnostic purposes and for connection to peripheral equipment (local display, BTU meter, etc.). All outputs shall be linear with flow rate.

D. The turbine elements shall be made of polypropylene with sapphire jewel bearings and tungsten carbide shafts. The flow sensor shall be constructed of 316 stainless steel with an aluminum electronics enclosure and gasketed cover.

E. Install flow measuring stations with minimum straight lengths of pipe upstream and downstream from sensor as prescribed by manufacturer's written instructions.

F. Make electrical connections to power supply and interlock with ATC system.

G. Calibrate meters per manufacturer’s requirements.

2.18. WATER METER

A. A building consumption water meter consumption meter shall be provided and installed under Division 23 Section, “Plumbing Fixtures” and “Plumbing Equipment”. Refer to plumbing sections and drawing for type and location. The ATC contractor shall provide all necessary wiring, relays, terminations, etc., as required to interlock meter with ATC system. Building water flow shall be reported on ATC central computer. Flow rate and volume should be reported in ATC system.

B. At Contractor's option the building water meter may be furnished and installed under this Division.

C. Trend, hourly, daily, monthly, and yearly water use (in gallons) and forward to Engineer for one year. Create graphic on ATC system.

2.19. FIELD INSTALLED CONDENSATE OVERFLOW SWITCHES

A. Condensate overflow switches must be tested to comply with U.L. 508.

B. Interlock condensate overflow switches to shut-down cooling equipment and alarm on ATC system where overflow condition exists.

2.20. CO2 SENSORS/TRANSMITTER

A. Furnish and install wall mount CO2 sensor/transmitters at locations indicated on floor plans. CO2 sensor/transmitter shall be model CD-W00 as manufactured by Johnson Controls or approved equal.

B. Measuring Range: 0 to 2,000 ppm CO2.

C. Response Time: 1 minute

D. Output Signal: As required by ATC system

E. Max power consumption: Less than 2 watts.

F. Listing: U.L. Listed

G. Accessories: Mounting Kit, Transformer required.

H. Where installed in gyms, auxiliary gyms, toilet rooms, locker rooms, cafeteria, and corridors install heavy duty stainless steel guards.

2.21. MECHANICAL FLOW SWITCHES (CONVENTIONAL WATER SOURCE EQUIPMENT)

A. Furnish and install piping flow switches at all water cooled equipment and additionally as shown on the Contract Documents.

B. Flow switches shall be Vaporproof, single pole double throw type as manufactured by McDonald and Miller or approved equal.

C. Enclosure shall be NEMA 4X rated for 150psig and suitable for temperatures between 0°F and 180°F with 1 inch MPT connection for upright mounting in horizontal pipe.

D. Size and select flow switches based on pipe size, insertion depth, pipe material and expected flow rate. Interlock status with ATC system.

E. At contractor’s option based on manufacturer’s requirements thermal dispersion flow switches may be utilized rather than mechanical flow switches.

2.22. EQUIPMENT WITH HEAD PRESSURE CONTROL VALVES - THERMAL DISPERSION FLOW SWITCHES

A. Furnish and install thermal dispersion flow switches in equipment with head pressure control valves as indicated on the Contract Drawings. The thermal dispersion flow switches shall be manufactured by IFM Efector, Inc., or approved equal. Coordinate exact chiller thermal dispersion flow switch requirements with the chiller manufacturer.

B. Units shall be normally open type and shall be interlocked to prevent chiller from operating until the fluid flow is proven. Unit shall be fully adjustable and include function display LED. Units shall be constructed of 316L stainless steel including housing and material surface sensor. All wetted surfaces shall also be constructed of 316L stainless steel.

C. Furnish with M12 connector and wiring for interface to chiller and automatic temperature control system. Coordinate wiring with ATC system and chiller control panel.

D. Install assembly, sensor, and adaptors as required.

2.23. DEW POINT TEMPERATURE SENSORS

A. Furnish and install dew point temperature sensors where indicated on the Contract Documents.

B. Dew point temperature sensor shall be model DP4AS as manufactured by TelAire or approved equal. Unit shall monitor dew point temperature and dry bulb temperature and report the same on the ATC system.

C. Units shall comply with the following:

Accuracy	
Enthalpy	± 2 BTU/lb
Dew Point Temperature	± 1.8°F (± 1°C)
Wet Bulb	± 3°F (± 1.7°C)
Dry Bulb	± 0.5°F (± 0.9°C)
Supply Voltage	18-30 VDCm 100 mA
Signal Output	Field selectable: 4-20 mA (700Ω max load), 0-5 V, or 0-10 V Humidity and dry bulb temperature
Measurement Range	
Dew Point: Space	40° to 90°F (4.4° to 32.2°C)
Enthalpy: Space	0-50 BTU/lb
Wet Bulb Space:	40° to 90°F (4.4° to 32.2°C)
Dry Bulb Space:	40° to 90°F (4.4° to 32.2°C)
Sensing Technology	Capacitive and replaceable
Operating Humidity	0 to 99% RH, non-condensing
Warranty	1 Year

D. Where installed in gyms, auxiliary, gyms, toilet rooms, and corridors install heavy duty stainless steel guards.

2.24. WALL-BOX TIMER SWITCHES

A. Digital Preset Timer

1. Description: Solid state interval time switch with backlit LCD display.

2. Features:

a. Adjustable Time Delay: 10, 20, 40, 60, 90 minutes/ 2, 4, 6, 8, hours.
b. Single button timer selection
c. LED indication
d. Silent operation
e. Requires neutral conductor
f. UL listed.
g. BAS/ATC system interface.
h. Override on/off.

3. Ratings:

a. 1 Amp at 30V maximum.

4. Electronic time switch shall be interlocked with ATC system and associated HVAC equipment.

5. Basis of Design: Tork Model SSA200R-24 (finish to match other wiring devices specified herein).

2.25. TOGGLE SWITCHES

A. Toggle switches shall be quiet-type, extra heavy-duty, horsepower-rated, industrial grade, 120/277V, 20A: Comply with NEMA WD 1, UL 20 and Federal Specification W-S-896. Switches shall have the following basic features:

1. Heavy-gauge one-piece copper alloy contact arm.
2. Fast "make" and positive "break" to minimize arcing.
3. Heavy-duty bumper pads for quiet operation.
4. High strength thermoplastic polycarbonate toggle.
5. Oversized silvery alloy contacts for long life and heat dissipation.
6. Nickel-plated steel strap with integral ground.
7. Auto-ground clip to assure positive ground.

B. Hubbell HBL1221 (single-pole), HBL1222 (two-pole), HBL1223 (three-way), HBL1224 (four-way), Pass & Seymour PS20AC1 (single-pole), PS20AC2 (two-pole), PS20AC3 (three-way), PS20AC4 (four-way), or approved equal by acceptable manufacturer.

C. Manual toggle switches shall be interlocked with ATC system and associated HVAC equipment.

PART 3. EXECUTION

3.1. GENERAL

A. The Automatic Temperature Control System and Central Control and Management System, shall be designed, installed, and commissioned in a turnkey fully implemented and operational manner.

3.2. BMS SPECIFIC REQUIREMENTS

A. Graphic Displays

1. Provide a color graphic system flow diagram display for each new system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.
2. User shall access the various system schematics via a graphical penetration scheme and/or menu selection.

B. Custom Reports:

1. Provide custom reports as required for this project:

3.3. WORKSTATION INSTALLATION

A. Desktop Workstations Installation:

1. Install workstation(s) at location(s) directed by Owner.
2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single duplex electrical power receptacle.
3. Install software on workstation(s) and verify software functions properly.
4. Develop Project-specific graphics, trends, reports, logs and historical database.
5. Power each workstation through a dedicated UPS unit. Locate UPS adjacent to workstation.

B. Portable Workstations Installation:

1. Turn over portable workstations to Owner at Substantial Completion.
2. Install software on workstation(s) and verify software functions properly.

C. Color Graphics Application:

1. Use system schematics indicated as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of all text for each graphic for Owner's review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Final editing shall be done on-site with Owner's review and feedback.
7. Refine graphics as necessary for Owner acceptance.

8. On receiving Owner acceptance, print a hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

3.4. INSTALLATION & SUPERVISION

A. All wiring and tubing shall be properly supported and run in a neat and workmanlike manner. All wiring and tubing exposed and in equipment rooms shall run parallel to or at right angles to the building structure. All piping and wiring within enclosures shall be neatly bundled and anchored to prevent restriction to devices and terminals.

B. The control contractor shall be responsible for all electrical installation required for a fully functional control and automation system and not shown on the electrical plans or required by the electrical specifications. All wiring shall be in accordance to all local and national codes.

1. All line voltage wiring, all wiring exposed, and all wiring in equipment rooms shall be installed in conduit in accordance to the electrical specifications.
2. All electric and electronic wiring shall be minimum #20 AWG minimum THHN and shielded if required.
3. All wiring in the central control room shall be concealed in an approved manner.

C. Verify locations of temperature sensors, relative humidity sensors, CO2 sensors, and other exposed control sensors with plans and Owner prior to installation.

D. The installation and supervision of this project shall be carried out by factory trained personnel who are employed by the Contractor and licensed for this type of work.

E. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.

F. Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation.

G. Install in accordance with manufacturer’s instructions.

H. Check and verify location of space temperature sensors, relative humidity sensors, CO2 sensors, and other exposed control sensors with plans and room details before installation. Align with lighting switches and relative humidity sensors, and dewpoint temperature sensors.

I. Mount freeze protection thermostats using flanges and element holders.

J. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors with sun shield.

K. Provide separable sockets for liquids and flanges for air bulb elements.

L. Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.

M. Install equipment plumb and level.

N. Install all equipment to be accessible for service and maintenance.

3.5. ACCEPTANCE TESTING

A. Point Verification

To verify end-to-end operation of the system the Contractor shall provide a hard copy of an All Points Summary Listing to the Owner of each part or system to be placed in warranty by the Owner. For CHS systems, the Contractor shall additionally provide a print screen of the process display showing real time dynamic point information for all points on the subsystem(s) to be accepted.

B. Sequence Verification

1. The Contractor shall notify the Owner's representative of systems which perform all specified sequences.
2. The warranty acceptance test shall be of 5 days duration and the system shall perform as follows:

   a. During the five days, the FMCS system shall not report any system diagnostics from the subsystem under test.
   b. The subsystem shall be performance verified as operational using temporary trends of each control loop located in the SDC or MSDC.
   c. During the occupied periods, BAS control loops, under test, shall maintain control of the process variable within the following scales:

      i. Duct Static Pressure +/-0.3 inch WC
      ii. Pump Head Pressure +/-10 percent of control range
      iii. Duct Temperature Loops +/-2 degrees F
      iv. Room Temperature Loops +/-1degrees F
      v. Pipe Temperature Loops +/-2 degrees F
      vi. Duct Relative Humidity +/-2x rated error of Humidity Transmitter
   d. The contractor shall provide a hard copy printout of the process variable, process variable set point and control loop output percent for the period of 2 hours prior to occupancy to 2 hours after occupancy with samples taken every 15 minutes.

3.6. COORDINATE WITH TAB AGENCY

A. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water reset, freeze stats and duct smoke detectors.

B. Verify that all controlling instruments are calibrated and set for design operating conditions prior to commencement of TAB work.

C. Calibrate sensors after installation, and before the sensor control verification tests are performed. Prove the accuracy of final settings by taking temperature readings. The readings shall be in a typical conditional space for each separately controlled zone.

D. Allow sufficient time in the project to provide assistance and instruction to the balancing agency in the proper use and setting of control components such as, but not limited to, computers, static pressure controllers, or any other device that may need set points changed so that the testing and balancing work can be performed.

E. All control sequences, software, equipment, and components shall be started-up by a qualified technician. Start-up report shall be submitted to Engineer prior to the commencement of testing and balancing work. Testing and balancing shall not commence until start-up reports are completed, reviewed by Engineer and forwarded to Testing and Balancing Agency.

3.7. EXAMINATION

A. Verify existing conditions before starting work.

B. Verify that systems are ready to receive work.

C. Beginning of installation means installer accepts existing conditions.

D. Sequence work to ensure installation of components is complementary to installation of similar components in other systems.

E. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

F. Verify that conditioned power supply is available to the control units and to the operator work station. Verify that field end devices, wiring, and tubing is installed prior to installation proceeding.

3.8. INTERLOCK REQUIREMENTS

A. The fan and equipment interlock requirements are as scheduled on the contract drawings.

B. Furnish and install all necessary relays, transformer, contactors, wiring, conduit, and accessories to perform fan, equipment, and damper interlocks.

C. Unless otherwise noted, fan interlocks shall be arranged such that dampers associated with fan shall be open when fan starts and close when fan stops.

D. Interlock ATC system with emergency generator system to provide emergency operation mode for geothermal pump and associated heat pumps.

3.9. SUBMITTALS AT PROJECT CLOSEOUT

A. Project Record Documents: Record actual locations of components and set points of controls, including changes to sequences made after submission of shop drawings.

3.10. CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to machine to allow service and maintenance.

B. Ground equipment.

1. 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.

C. Connect hand-off-auto selection switches to override automatic interlock controls when switch is in hand position.

3.11. FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.
8. Test all end switches and verify status is reported on the ATC system.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
6. Check temperature instruments and material and length of sensing elements.
7. Check control valves. Verify that they are in correct direction.

8. Check DDC system as follows:

    a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

E. All temperature control and interlock wiring shall be installed in conduit unless otherwise noted on the plans. Power or interlock wiring shall be run in separate conduit from sensor and communications wiring.

3.12. ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:

    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using volt-ohm-milli-amp meter (VOMA) at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:

    a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 0, 50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:

    a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:

a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers.
9. Provide diagnostic and test instruments for calibration and adjustment of system.
10. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial CO_2, temperature, and relative humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.13. ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested by 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.

3.14. SCHEDULING

A. Submit spreadsheet to Owner indicating occupied/unoccupied times for each item controlled by ATC system. Incorporate all scheduling requirements into sequence of operation.

3.15. STAGING

A. Coordinate staging requirements with equipment being controlled. Where multistage units are scheduled or specified, provide all devices, controllers, wiring to control and sequence all stages.

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SECTION 23 09 23 – AIRFLOW MONITORING STATIONS

PART 1. GENERAL

1.1. RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

A. Section Includes:

1. Airflow measurement stations and sensors.
2. Airflow switches.
3. Airflow transmitters.

B. Related Requirements:

1. Section 230900 "Instrumentation and Controls of HVAC and Plumbing Systems" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3. DEFINITIONS

A. Ethernet: Local area network based on IEEE 802.3 standards.

B. FEP: Fluorinated ethylene propylene.

C. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.

D. PEEK: Polyetheretherketone.

E. PTFE: Polytetrafluoroethylene.

F. PPS: Polyphenylene sulfide.

G. RS-485: A TIA standard for multipoint communications using two twisted pairs.

H. RTD: Resistance temperature detector.

I. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

1.4. ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.
5. Product certificates.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for air and process signal tubing.
5. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Delegated-Design Submittal:

1. Schedule and design calculations for flow instruments, including the following.

   a. Flow at Project design and minimum flow conditions.
   b. Pressure drop at Project design and minimum flow conditions.

1.5. INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.

B. Product Test Reports: For each product, for tests performed by manufacturer and witnessed by a qualified testing agency.

C. Documentation of NIST traceability.

1.6. CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

1.7. MAINTENANCE MATERIAL SUBMITTALS

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

B. Provide parts, as indicated by manufacturer's recommended parts list, for product operation during two-year period following warranty period.

PART 2. PRODUCTS

2.1. PERFORMANCE REQUIREMENTS

A. Delegated Design: Select and size products to achieve specified performance requirements.

B. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2. GENERAL REQUIREMENTS FOR FLOW INSTRUMENTS

A. Air sensors and transmitters shall have an extended range of 10 percent above Project design flow and 10 percent below minimum Project flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

B. Source Limitations: For flow instruments, obtain products from single source from single manufacturer.

2.3. AIRFLOW MEASUREMENT

A. General Requirements:

1. Adjustable for changes in system operational parameters.
2. Airflow Sensor and Transmitter Range: Extended range of 10 percent above Project design flow and 10 percent below minimum Project flow to signal abnormal flow conditions.
3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.

    a. Product certificates are required.

4. System Accuracy: The total system accuracy, including array averaging error, transducer error, etc… when installed in accordance with the manufacturer’s recommendations and without field adjustment shall be as follows throughout the entire operating range.

    a. Ducts and plenums: +/- 3% of reading
    b. Outside air intakes +/- 5% of reading
    c. Fan inlets +/- 10% of reading

5. Recalibration:

    a. If the technology provided requires recalibration, the contractor shall be responsible for recalibrating the system on a semi-annual basis during the construction phase through the end of the project warranty period.

6. Product Applications

   a. Select from instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

      i. The contractor will be required as part of the submittal process to provide a working demo that demonstrates that the unit will operate at the lowest air flows possible on the project. If the manufacture is unable to provide a working demo than their submittal will not be reviewed by the design team.

   b. Duct-Mounted Airflow Sensors:

      i. Measured Velocities 500 fpm and Less:
         1) Thermal dispersion airflow station.
      ii. Measured Velocities Greater than 500 fpm:
         1) Thermal dispersion airflow station

B. Duct Mounted Thermal Dispersion Airflow Measuring Station:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Ebtron: Gold Series. (Basis of Design)
   b. Air Monitor Corporation: Electra-Flo

2. Source Limitations: Obtain airflow and temperature measuring sensors and transmitters from single manufacturer.
3. Description: Airflow station shall consist of one or more sensor probes and a remotely mounted microprocessor-based transmitter.
4. Performance:

   a. Capable of independently processing up to 16 independently wired sensor assemblies.
   b. Airflow rate of each sensor assembly shall be equally weighted and averaged by transmitter prior to output.
   c. Temperature of each sensor assembly shall be velocity weighted and averaged by transmitter prior to output.
   d. Listed and labeled by an NRTL as successfully tested as an assembly according to UL 873, "Temperature-Indicating and Regulating Equipment."
   e. Components shall be interconnected by exposed NRTL-listed plenum-rated cable or non-listed cable placed in conduit.
   f. Each flow station shall be factory calibrated at a minimum of 16 airflow rates and three temperatures to standards that are traceable to NIST.
   g. Airflow Accuracy: Within 2 percent of reading over the entire operating airflow range, with 0.25 percent repeatability.

      i. Devices whose accuracy is combined accuracy of transmitter and sensor probes must demonstrate that total accuracy meets the performance requirements throughout the measurement range.

h. Temperature Accuracy: Within 0.15 deg F over entire operating range of minus 20 to plus 160 deg F.
i. Sensor Ambient Operating Temperature Range: Minus 20 to plus 160 deg F.
j. Transmitter Ambient Operating Temperature Range: Minus 20 to plus 120 deg F.
k. Sensor and Transmitter Ambient Operating Humidity Range: Zero to 99 percent, non-condensing.
l. Instrument shall compensate for changes in air temperature and density throughout calibrated velocity range for seasonal extremes at Project location.
m. Pressure Drop: 0.05-inch wg at 2000 fpm across a 24-by-24-inch area.
n. Instruments mounted in throat or face of fan inlet cone shall not negatively influence fan performance by reducing flow more than 1 percent of Project design flow or negatively impact fan-generated sound. Losses in performance shall be documented with submittal data, and adjustments to compensate for performance impact shall be made to fan in order to deliver Project design airflow indicated.

5. Sensor Assemblies:

a. Each sensor probe shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
b. Mount thermistors in sensor using a marine-grade, waterproof epoxy.
c. Thermistor leads shall be protected and not exposed to the environment.
d. Each sensor assembly shall independently determine airflow rate and temperature at each measurement point.
e. Each sensor probe shall have an integral cable for connection to remotely mounted transmitter.
f. Sensor Probe Material: Gold anodized, extruded 6063 aluminum tube or Type 316 polished stainless steel.
g. Probe Assembly Mounting Brackets Material: Type 304 stainless steel.

6. Transmitter:

a. Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.
b. Capable of field configuration and diagnostics using an onboard push-button interface and digital display.

i. Include an integral power switch to operate on 24-V ac (isolation not required) and include the following:

1) Integral protection from transients and power surges.

2) Circuitry to ensure reset after power disruption, transients, and brownouts.

3) Integral transformer to convert field power source to operating voltage required by instrument.

2.4. AIRFLOW TRANSMITTERS

A. Airflow Transmitter with 0.10 Percent Accuracy and Auto-Zero Feature:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Ebtron
    b. Air Monitor Corporation: Veltron Mass-tron II

2. Transmitter shall receive total- and static-pressure signals from a primary element, amplify signals, extract the square root, and scale the signals to produce 4- to 20-mA dc output signals linear to airflow.
3. Transmitter shall have built in capability for both process temperature and pressure compensation.
4. NEMA 250, Type 1 enclosure.
5. Construct assembly so that shock, vibration, and pressures surges of up to 1 psig will neither harm transmitter, nor affect its accuracy.
6. Transmitter shall include automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals. The automatic zeroing circuit shall re-zero transmitter to within 0.1 percent of true zero.
7. Performance:

    a. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
    b. Calibrated Span: Field adjustable, minus 40 percent of the range.
    c. Accuracy: Within 0.10 percent of natural span.
    d. Repeatability: Within 0.15 percent of calibrated span.
    e. Linearity: Within 0.2 percent of calibrated span.
    f. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.

8. Integral multi-line digital LED or digital display for continuous indication of airflow.

PART 3. EXECUTION

3.1. EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Provide the services of an independent inspection agency to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

1. Indicate dimensioned locations with mounting height for all surface-mounted products to walls and ceilings on shop drawings.
2. Do not begin installation without submittal approval of mounting location.

E. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

F. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.2. INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to force.

D. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.3. ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Refer to Division 26.

C. Furnish and install power wiring. Refer to Division 26.

D. Furnish and install raceways. Refer to Division 26.

3.4. INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.

2. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Unless indicated otherwise, mount switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches (1050 to1800 mm) above the adjacent floor, grade, or service catwalk or platform.

   a. Make every effort to mount at 60 inches (1500 mm).

3. Where indicated for rooftop equipment, mount display within rooftop equipment.

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.5. FLOW INSTRUMENTS INSTALLATION

A. Airflow Sensors:

1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
2. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

B. Transmitters:

1. Install airflow transmitters serving an air system in a single location adjacent to or within system control panel.

3.6. IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Division 26.

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.7. CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.8. CHECKOUT PROCEDURES

A. Description:

1. Check out installed products before continuity tests, leak tests, and calibration.
2. Check instruments for proper location and accessibility.
3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

B. Flow Instrument Checkout:

1. Verify that sensors are installed correctly with respect to flow direction.
2. Verify that sensor attachment is properly secured and sealed.
3. Verify that processing tubing attachment is secure and isolation valves have been provided.
4. Inspect instrument tag against approved submittal.
5. Verify that recommended upstream and downstream distances have been maintained.

3.9. ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by

an instrument with an accuracy of 0.5 percent.

7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after-calibration-indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.10. DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION

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SECTION 23 21 13.33 - GROUND LOOP HEAT PUMP PIPING

PART 1. GENERAL

1.1. SUMMARY

A. This Section includes the following:

1. Exterior piping for horizontal, closed loop, ground source heat exchanger systems.
2. Exterior piping for vertical, closed loop, ground source heat exchanger systems.

B. Related Sections include the following:

1. Division 23 Section HVAC Piping, Fittings and Valves for Interior Geothermal Energy Recovery Piping.
2. Division 23 Section Heating, Ventilating and Air Conditioning Equipment for Geothermal Heat Pump Equipment.
3. Division 31, 32, and 33 Sections.

1.2. REFERENCES

A. Industry Standard and Specifications

1. International Ground Source Heat Pump Association (IGSHSPA):

a. Closed-loop/Geothermal Heat Pump Systems, Design and Installation Standards.
b. Closed-loop/Ground Source Heat Pump System, Installation Guide.
c. Grouting Procedures for Ground Source Heat Pump Systems.

2. American Society for Testing and Materials (ASTM):

a. ASTM D 2239-96a Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.
b. ASTM D 2657-97 Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings.
c. ASTM D 2683-98 Specification for Socket-Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing.
d. ASTM D 2774-94 Practice for Underground Installation of Thermoplastic Pressure Piping.
e. ASTM D 3035-95 Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
f. ASTM D 3261-97 Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
g. ASTM F 645-95 Guide for Selection, Design and Installation of Thermoplastic Water Pressure Piping Systems.
h. ASTM D 1785 – Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Schedules 40, 80, and 120.
i. NSF 14 – Plastic Piping System Components and Related Materials
j. NSF 61 – Drinking Water Systems Components – Health Effects

1.3. DEFINITIONS

A. GHEX: Closed loop, ground source heat exchanger.

B. PE: Polyethylene plastic.

1.4. SUBMITTALS

A. Product Data: Include manufacturer's catalogue sheets, specifications, and installation instructions for GHEX piping, closed cell insulation, and grout material. Include piping type, schedule, class of pipe and fittings.

B. Shop Drawings: Diagram vertical and horizontal piping and interface with interior header piping within building.

C. Calculations: Grout volume calculations and flushing/purging flow rates and pressure drops.

D. Samples: Furnish 12 inch long sample of GHEX piping illustrating U-bend fitting and joining.

E. Quality Control Submittals:

1. Geothermal System Installer's Qualifications Data:

    a. Name of each person who will be performing the geothermal work and their employer's name, business address, telephone number, fax number and e-mail address.
    b. Names and addresses of three similar projects that each person has worked on.
    c. Copy of installer's personal certification for polyethylene pipe fusion techniques from IGSHPA or piping manufacturer.

2. Geothermal System Supervisor's Qualifications Data:

    a. Name of person overseeing the geothermal work and their name, business address and telephone number.
    b. Name and address of three similar projects that the supervisor has overseen during the past five years.
    c. Copy of supervisor's personal certification for polyethylene pipe fusion techniques from IGSHPA or piping manufacturer.

3. Geothermal System Contractor's Qualifications Data

    a. Name and addresses of three geothermal projects of similar size and complexity that the supplier has worked on during the past five years.

4. Company Field Advisor Data:

    a. Name, business address and telephone number of Company Field Advisor secured for the required services.

b. Certified statement from the company listed the qualifications of the Company Field Advisor.
c. Services and name of each product for which authorization is given by the Company, listed specifically for this project.

1.5. QUALITY ASSURANCE

A. Geothermal System Installer Qualifications: The person performing geothermal work shall be personally certified in polyethylene pipe fusion techniques by IGSHPA or piping manufacturer, personally experienced in geothermal work, and shall have been regularly employed by a company performing geothermal work for a minimum of three years.

B. Field Advisor Qualifications: IGSHPA certified installer or IGSHPA certified designer shall qualify as Field Advisor.

C. Geothermal System Supervisor's Qualifications: The persons overseeing the geothermal work shall be personally certified in polyethylene pipe fusion techniques by IGSHPA or piping manufacturer, personally experienced in geothermal work, and shall have been regularly employed by a company performing geothermal work for a minimum of three years.

D. Geothermal System Supplier Qualifications: The contractor shall have completed geothermal work on at least three projects of similar size and complexity within the last five years.

E. Company Field Advisor: Secure the services of a Field Advisor for a minimum of 12 working hours for the following:

1. Render advise regarding installation and final adjustment of the system.
2. Witness on site bore hole locations in the presence of the Owner's representative.
3. Certify that vertical bore holes meet design depth, and do not exceed a 5% differential in depth from one bore hole to another.
4. Witness pressure testing of horizontal and vertical underground polyethylene piping, in the presence of the Owner's representative.
5. Witness the back-filling of horizontal pipes trenches.
6. Witness final system test, then certify with an affidavit that the system is installed in accordance with the Contract Documents and is operating properly.

F. Regulatory Requirements:

1. Perform factory testing of factory fabricated equipment in complete accordance with the agencies having jurisdiction.
2. Perform field testing of piping systems in complete accordance with the local utilities and other agencies having jurisdiction and a specified.

1.6. COORDINATION

A. Coordinate GHEX piping installation with exterior utilities, structures and site work.

B. Coordinate GHEX piping with interior GHEX piping at headers within mechanical room. Coordinate terminations locations within mechanical room. Verify that GHEX piping can be installed to comply with original design and referenced standards.

1.7. DELIVERY, STORAGE AND HANDLING

A. Deliver piping 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. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

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

D. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.8. PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Engineer not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Engineer written permission.
3. Prior to excavation of well drilling, provide test pits to locate existing utilities where geothermal U-tubes and horizontal piping are to be installed.

B. Temporary Facilities: Provide temporary well when required to provide water for well drilling operations. Well size, depth, and location shall be determined based on requirements to allow well drilling operations. Furnish and install the following:

1. Permits for temporary well.
2. Temporary electric service and/or generator.
3. Freeze protection of well head.

C. Remove temporary well and all associated equipment, wiring, and piping at completion of well field installation.

D. Provide and pay for all necessary permits for this portion of the project. Contact local Health Department and DNREC regarding permit requirements and costs and include in bid.

1.9. WARRANTY

A. Manufacturer's Warranty: Minimum 50 years warranty for PE piping and butt fusion welds.

B. Manufacturer shall replace or repair PE piping that fails within the 50 year warranty period due to defects in the piping.

PART 2. PRODUCTS

2.1. VERTICAL U TUBES

A. PE Pipe: ASTM D 3035, made of PE 3408 compound, or PE 4710 with dimension ratio not greater than DR 11, to provide pressure rating of at least 160 psig (1104 kPa) at 73 deg F (23 deg C). Provide with UV stabilizer.

1. PE Fittings: ASTM D 3261, PE butt fusion type fittings made of PE compound similar to PE pipe, matching pipe OD, and with pressure rating at least equal to PE pipe. Provide with UV stabilizers.
2. Markings: Pipe shall be marked with manufacturer’s name and product name, nominal size, ASTM dimensional standard, PPI material classification, cell classification, sequential footage, and manufacturer’s date code. Print line shall repeat every two feet.

2.2. DIRECT BURIED HORIZONTAL PIPING

A. ASTMD 3035, made of PE 3408 compound, or PE 4710 with dimension ratios no greater than DR 13.5 to provide pressure ratio of at least 128 psig at 73 degrees F. Provide with U.V. stabilizer.

1. PE Fittings: ASTM D 3261, PE butt fusion type fittings made of PE compound similar to PE pipe, matching pipe OD, and with pressure rating at least equal to PE pipe. Provide with UV stabilizers.
2. Markings: Pipe shall be marked with manufacturer’s name and product name, nominal size, ASTM dimensional standard, PPI material classification, cell classification, sequential footage, and manufacturer’s date code. Print line shall repeat every two feet.

2.3. THERMALLY ENHANCED GROUT

A. Geothermal grout consisting of specially blended, high -solids bentonite and sand in a two-part thermally conductive grouting material. Paddle mix grout with minimum shearing action and agitation of the slurry.

B. Geothermal grout, low permeability 1 x 10 –7 cm/sec, 65 to 70% solids as manufactured by CETCO, Baroid, Black Hills as manufactured by GeoPro, Inc., or approved equal. At contractor’s option GA-Xtra one part conductive geothermal grout as manufactured by Geo Energy Alternatives may be utilized.

C. Minimum thermal conductivity (k) = 1.0 BTU/HR-Ft -degrees Fahrenheit.

D. Grout sand shall be 50 to 70 mesh with 99% silicia content. Sand shall be ANSI/NSF Standard 60 certified.

2.4. CLOSED CELL INSULATION

A. Closed Cell Insulation: one (1) inch thick, high density (5lb/cu ft), pre-formed pipe insulation of rigid, expanded, closed cell structure. Comply with ASTM C1126, Type III, Grade 1.

2.5. BACKFILL SAND

A. The first 24 inches of backfill adjacent to the horizontal piping shall be backfill sand that shall comply with ASTM C-33. Six (6) inches of sand shall be provided for bedding of the piping. Refer to detail on Contract Drawings.

B. Sand shall be free of rocks, clumps, and other debris.

PART 3. EXECUTION

3.1. EXAMINATION

A. Prior to any excavation, trenching or drilling, all buried utilities, drainage systems, irrigation systems shall be located and flagged by the appropriate utility and contractor representative's.

3.2. HORIZONTAL GHEX SYSTEM INSTALLATION

A. Separate trenches by 10 feet (3 m) minimum. Remove sharp rocks in trenches that could contact pipe.

B. Utilize excavated soils or sand for bedding of piping.

C. Backfill to 24 inches (600mm) above pipe with sand. Backfill from sand to grade with excavated soil, compact as required.

D. Clean PE pipe and fittings for loop. Minimize number of joints.

E. Install PE piping in trenches according to ASTM D 2774 or ASTM F 645.

F. Purge, flush, and pressure test piping before backfilling trenches.

G. Install piping in pipe trenches after cushion material bedding has been placed and completed.

1. Minimum Pipe Depth: 48" below finished grade.
2. Insulate piping at wall penetrations, within 5 feet of building, below sidewalks or where located below building.

H. Separate supply and return lines or bundles a minimum of 6-12 inches to minimize thermal interference.

I. Minimize the number of points where supply and return lines cross one another.

J. Install piping of such lengths to minimize the number of fusion joints required.

K. Avoid sharp bends in piping, use elbows where required.

L. Install bell reducing fittings or reducing tees at pipe reductions to eliminate trapped air.

M. Cap open end of pipe to prevent entry of contaminants until final connections are made.

N. Pressure test piping after connecting to vertical well piping.

O. Route horizontal piping around drip lines of trees.

P. Where excavations are over 5 feet deep, provide sloped walls of trenches per OSHA requirements.

3.3. VERTICAL GHEX SYSTEM INSTALLATION

A. Clean PE pipe and fittings for loop. Minimize number of joints.

B. Install PE piping in wells according to ASTM D 2774 or ASTM F 645.

C. Purge, flush, and pressure test piping before grouting well.

D. After installation of loop pipe in well, pump grout to discharge at base of well. Fill well with grout to surface. Owner's representative shall be notified for inspection upon completion of grouting. Document results in writing and submit to Architect.

E. The holes or bores shall be clean and of sufficient diameter to facilitate the installation of the U-tube assembly. Reasonable care shall be taken not to crush, cut or link the pipe. If damaged, it shall be repaired, at no additional cost to the Owner.

F. Remove all cutout material remaining in well from drilling process before installing well piping.

G. Vertical piping shall be factory assembled:

1. Manufacturer shall construct down-hole closed-loop piping from two continuous lengths of pipe with U-bend joints at the bottom of the well.
2. Manufacturer shall mark piping in one foot (1) increments and stencil on the piping the total distance from each increment to the U-bend. This will be accomplished so that the Engineer/Owner can verify depth of wells after piping is installed.
3. Manufacturer shall hydrostatically test the assembled vertical piping at 1.5 times the maximum working pressure, but not less than 100 psig, for four hours.
4. Manufacturer shall cap piping assembly before shipment

H. Provide fittings required for pressure testing.

I. Immediately after insertion into well, fill piping with water until it runs clean. The water in piping is intended to counteract the buoyancy effect. Attach additional counterweights as necessary to bottom of piping for deep wells.

J. Cap upper ends of well piping until connection to horizontal manifold is made.

K. Pressure grout well hole from bottom up with bentonite clay grout in accordance with IGSHPA installation manual. Monitor each well and continue adding grout where settlement has occurred.

L. Connect vertical piping to horizontal manifolds and pressure test entire underground system, before back-filling trenches.

M. Pipe Joint Makeup:

1. Polyethylene Butt or Saddle (side wall) Fusion Pipe Joints: Follow the manufacturer's printed installation instructions.
2. Dissimilar Pipe Joints:

   a. Joining Dissimilar Threaded Piping: Make-up connection with a threaded coupling or with companion flanges.
   b. Joining Dissimilar Non-Threaded Piping: Make-up connection with adapters recommended by the manufacturers of the piping to be joined.

N. Layout wellfield so that drilling equipment is at least 15 feet away from building structure.

3.4. JOINT CONSTRUCTION

A. Clean PE pipe and fittings and make heat fusion joints according to ASTM D 2657.

B. The fusion machine shall encompass the following features:

1. Guide rods shall be in the plane that passes through the centerline of the pipe thus canceling the bending forces in the machine caused by the fusion forces.
2. The combination butt/saddle machine must have a mechanical advantage of at least 5.5 to 1 in the butt fusion mode, and 2.5 to 1 in the saddle fusion mode. A butt fusion only machine shall have a mechanical advantage of at least 10 to 1 and saddle fusion only machine must be capable of applying at least 600 lbs of thrust.
3. The pipe clamps shall have the strength to "round-up" the pipe closed to the fusion joint. They shall be adjustable for removal of high/low mismatch of pipe walls, and clamp each piece on the continuing straight centerline.
4. The pipe facing device shall be capable of rapid facing of the pipe ends to a perfectly flat surface, so when the ends are brought together, there is 100% plastic contact. The facer shall be hand-powered for pipe sizes up to 2", electrically powered up to 8", and hydraulically powered for sizes larger than 8". The facer shall have precisely machined stops to lock the facer squarely between the clamping jaws at the end of face off.
5. The heater plate shall be electrically heated and thermostatically controlled. The surface shall be smooth with a high quality non-stick coating. The heater shall be capable of quick heat-up and maintaining a constant surface temperature in the desired temperature range even in inclement conditions. The heater plate shall be equipped with a thermometer to monitor proper temperature.

C. No joints in vertical tubing; maximum two joints at return U-bend.

3.5. CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect GHEX system piping to headers within mechanical rooms.

3.6. FIELD QUALITY CONTROL

A. Piping Tests: Conduct piping tests before joints are covered. Fill piping 24 hours before testing and apply test pressure to stabilize system. Use only potable water.

B. Preliminary Work: Thoroughly clean pipe and tubing prior to installation. During installation, prevent foreign matter from entering systems. Prevent if possible or remove obstructions from piping and systems.

C. Flushing, Purging, Pressure and Flow Testing:

1. All fusion joints and loops lengths shall be checked to verify that no leaks have occurred in shipping or in fusion joining.
2. All loops shall be pressure tested before installation, and all horizontal components of the ground heat exchanger shall be pressure tested prior to back-filling.
3. Heat exchangers shall be tested hydrostatically at 100 psig. Do not test until every joint has set and cooled at least 8 hours. Maintain test pressure for 24 hours. Record trench temperature at start and finish of pressure test. There shall be no reduction in applied test pressure other than that due to a change in ambient temperature. Use test gage with one psi increment and readable to 1" psi.
4. Before connection (header), trenches are backfilled, piping shall be pressure tested with water at 100 psig for 1 hour with no drop in pressure greater than 10 psig.
5. Site conditions may dictate backfilling prior to testing with water. A minimum air pressure of 45 psi shall be maintained on the ground heat exchanger during backfilling and until the final pressure test with water can be conducted.
6. After the conclusion of the ground heat exchanger pressure test, the ground heat exchanger shall be left filled with clean water and maintained under pressure until final connection to the building system.
7. Start-up pressurization of the circuit to minimum of 20 to 30 psi (1.38 – 2.07 bar) when installed in the summer with circulating water temperature of 70-90°F (20-30°C) and 40 to 50 psi (2.76-3.45 bar) when installed in the winter with circulating water temperature of 40-50°F (5-10°C) is required. Standing column designs of circulating systems that ensure a flooded volute and meet the manufacturer’s requirements are excluded from these pressure requirements.
8. Loop charging valve handles must be removed and/or the ports sufficiently plugged to prevent accidental discharge of system fluid and pressure.
9. All pipes passing through walls shall be sleeved and sealed with non-hardening caulking material.
10. Cleaning: Flush systems and apparatus, upon completion of pressure and miscellaneous test. Completely open valves and flush each system with clean water, prior to chemical cleaning. Repeatedly flush at short intervals until twice the system water capacity has been flush through. Chemically clean systems immediately following flushing operations. Circulate a solution consisting of trisoldium phosphate, in a proportion of one pound of chemical to every 50 gallons of water in the system. Completely fill system with cleaning solution; vent system and place in operation, with automatic controls operating and valves fully open. Allow system to reach design operating temperature. Circulate the solution through the system for a minimum of 4 consecutive hours; immediately drain and verify that flushing fluid matches clean water input. Keep strainers unplugged during cleaning operations. Remove and clean strainer screens prior to operational test. Refill system with clean water.

11. Flow rates and pressure drops shall be compared to calculate values to assure that there is not blockage or kinking of any pipe.
12. A minimum velocity of 4 ft/sec in each piping section must be maintained for a minimum of 15 minutes to remove all air. A change of more than one inch in the level of fluid in the purge pumps tank during pressurization indicates air is still trapped in the system.

D. Prepare reports of testing activities.

E. Balancing: Balance pipe loop flow to quantities indicated on drawings.

F. Follow Code required stormwater, sediment, and erosion control requirements.

3.7. IDENTIFICATION

A. Install continuous underground detectable warning tape for underground piping. Locate below finished grade, 24 inches above the piping.

B. Detectable Warning Tape: Acid-and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1mm) thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored as follows:

1. Blue: Geothermal Heat Pump Water systems.

C. Submit record drawings. Utilize global positioning system device to locate all lines and vertical U-tubes. Update the record drawings daily. Demonstrate GPS coordinates of GPS device matches locations of pipes and U-tubes prior to final backfill and grading.

3.8. ANTIFREEZE USE

A. Antifreeze solutions must meet local and state requirements and be acceptable by component manufacturers.

B. All GHP systems must be labeled and identified at the loop charging valves. The labels must be of a permanent type with the following information:

1. Antifreeze type and concentration
2. Service date
3. Company name
4. Company phone number and responsible party or person.

3.9. RESTORATION OF EXISTING LAWN

A. Restore, re-grade, and re-seed all lawns disturbed by the installation of the geothermal piping. General turf grass – Rebel Supreme tall Fescue Blend or approved equal for re-seeding. Reuse surface soil stock piled on site and provide additional imported topsoil to provide minimum 3-4 inch layer of topsoil. Provide erosion control for newly seeded areas. Maintain and establish lawns by watering, fertilizing, weeding, mowing, trimming, and replanting and other operations. Roll, re-grade, and replant bare or eroded areas and replant to produce uniformly smooth lawn.

B. Remove from the site all soils unsuitable for backfilling.

C. See Division 23 Sections regarding grading and seeding.

D. Remove from the site drilling fluids. Do not discharge drilling fluids into streams, lakes, rivers, or ponds.

E. Install sediment and erosion control measures as required by the State of Delaware Requirements and as indicated on the Civil Engineering Contract Documents.

3.10. PIPELINE TRENCH BACKFILL

A. Materials excavated from the trench except topsoil shall be used for trench backfill, (except for backfill sand where required), provided that, in the opinion of the Engineer, the excavated material is suitable for this purpose. Backfill material shall be free from large lumps, pavement, pieces of concrete and stones.

B. Backfill material shall be placed in 8” loose layers above backfill sand. Compaction for 8” layers shall be accomplished by mechanical tampers or other approved methods. Care shall be taken in the use of mechanical tampers not to injure or move the pipe or to cause the pipe to be supported unevenly. Each layer shall be mechanically tamped for the full trench width.

C. Every backfill layer shall be compacted to 95% of maximum density at -2 to +2% of optimum moisture content as determined by the Standard Proctor Test, ASTM D-698. Materials containing an excess of moisture shall be permitted to dry until the moisture content is within the specified range. Materials too dry shall be wetted uniformly, at the Contractor’s expense, until the moisture content is in the specified range.

D. No compacting shall be done when the material is too wet to be compacted properly. At such times, the work shall be suspended until the backfill materials have dried sufficiently to permit proper compaction or such other precautions shall be taken as may be necessary to obtain proper compaction. The Contractor is responsible for hauling, storing and drying of excavated material to be used in backfill operations within the prices bid.

E. The Contractor shall, at his own expense, maintain all refilled excavations in proper condition. Trench surfaces shall be reshaped when necessary. If the Contractor fails to make repairs within forty-eight (48) hours after receipt of written notice from the Owner, the Owner may refill said depression wherever necessary and the cost of so doing will be retained from any monies due or to become due the Contractor under the Contract. The Contractor shall be fully responsible for any injury or damage that may result from lack of maintenance of any refilled excavation at any time prior to final acceptance.

F. All unauthorized excavations made by the Contractor shall be immediately backfilled in accordance with the requirements of the specifications for trench backfill at the Contractor’s expense.

G. After completion of backfilling, all material not used shall be disposed of off-site and all places on the line of the work shall be left clean and in good condition. The cleaning up shall be done by the Contractor without extra compensation. If he fails to do this work within a reasonable time after receipt of notice, it will be performed by the Owner, and the cost will be retained from the monies due the Contractor under the Contract.

H. No backfilling of pipelines will be allowed until measurements of pipe, pipe pressure tests and an inspection has been performed and witnessed by the Engineer and until the Engineer has authorized the backfill. Any unauthorized backfill of pipelines shall be uncovered by the Contractor at his expense if required by the Engineer.

END OF SECTION

DIVISION 23 SECTION 23 30 00
HVAC AIR DISTRIBUTION
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SECTION 23 30 00 - HVAC AIR DISTRIBUTION

PART 1. GENERAL

1.1. SUMMARY

A. For General Mechanical Requirements, see Division 23 Section, "Common Work Results for HVAC" and Division 01, "General Requirements".

B. The fabrication and installation of all ductwork, together with related equipment, shall comply with the standards of the National Fire Protection Association, as set forth in NFPA Standard No. 90A, as well as with the requirements of the Sheet Metal and Air Conditioning Contractors' National Association, Inc., and the latest edition of the ASHRAE Guide.

C. All duct sizes shown are net inside clear dimensions. Where internal duct lining is used, increase duct sizes accordingly to provide the indicated net free area. Unless otherwise indicated size runouts, drops, and connections to air handling equipment, grilles, registers, diffusers, fans, coils, louvers, filters, and other equipment to the full size of the equipment connection.

D. Minor changes may be made in duct sizes where required to fit the available space, provided the indicated net free area and approximate aspect ratio are maintained. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE/SMACNA Table of equivalent rectangular and round ducts.

E. Smoothly transition all ductwork to prevent excessive or unnecessary turbulence or pressure loss.

F. All exposed ductwork in finished areas shall be painted in color as indicated by Architect. All ductwork requiring paint shall be constructed of paint grade galvanized sheet steel with a paintable finish. All ductwork exposed to chemicals or shall be corrosion resistant and shall include a corrosion resistant finish.

1.2. REFERENCES

A. ASTM A 36 - Structural Steel

B. ASTM A 90 - Weight of coating on Zinc-Coated (Galvanized) Iron or Steel Articles

C. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

D. ASTM C 916 Type II – Standard Specification for Adhesives for Duct Thermal Insulation

E. ASTM A 366 - Steel, Sheet, Carbon, Cold Rolled, Commercial Quality

F. ASTM A 480 - General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

G. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process

H. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock

Forming Quality

I. ASTM A 568 - Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled

J. ASTM A 569 - Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Sheet and Strip, Commercial Quality

K. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate

L. AWS D9.1 - Welding of Sheet Metal

M. NFPA 90A - Installation of Air Conditioning and Ventilating Systems

N. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems

O. NFPA 96 - Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment.

P. SMACNA - HVAC Air Duct Leakage Test Manual

Q. UL 181 - Factory-Made Air Ducts and Connectors.

R. NFPA 90A - Installation of Air Conditioning and Ventilating Systems

S. NFPA 70 - National Electrical Code

T. SMACNA - HVAC Duct Construction Standards - Metal and Flexible

U. UL 33 - Heat Responsive Links for Fire-Protection Service.

V. UL 555 - Fire Dampers

1.3. QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the projects specified in this section with minimum five (5) years documented experience.

B. Installer: Company specializing in performing the work of this section with minimum five (5) years’ experience.

1.4. REGULATORY REQUIREMENTS

A. Construct ductwork to NFPA- 90A, NFPA-90B, and NFPA- 96 Standards.

1.5. ENVIRONMENTAL REQUIREMENTS

A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturer.

B. Maintain temperatures during and after installation of duct sealants.

1.6. ALTERNATES

A. Refer to Division 01 Section, “Alternates” for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. DUCTWORK

A. Unless otherwise indicated or specified, fabricate ductwork of galvanized sheet steel, stainless steel, or aluminum conforming to Commercial Designation 3003 Temper H14 and Duct Sheet. Duct gages, jointing and reinforcement shall conform to Tables 4, 5, 6 and 7, as applicable, Chapter I of the latest ASHRAE Guide and Data Book. Construction details shall conform to Section I and Section II, as applicable, of Duct Manual and Sheet Metal Construction for Ventilation and Air Conditioning Systems as published by Sheet Metal and Air Conditioning Contractors' Association, Inc.

B. Erect sheet metal ductwork in a first-class, workmanlike manner secured in place rigidly and permanently. Provide suitable hangers, securely attached to building construction with bolts, clips or inserts. Hangers shall be structural shapes, unistrut, kindorf or channel; strap hangers or the use of wire will not be permitted. All thread hangers shall not pass through or be inside duct. Hangers shall not penetrate the duct insulation vapor barrier. Support vertical ducts passing through floors by angles riveted to duct and resting either on floor or on brackets secured to building construction. All space around ducts where they pass through any walls, floors, ceilings, or roofs shall be sealed tight with incombustible inert material. Do not arrange ducts so as to impair the effectiveness of fireproofing around structural members. Provide sheet metal flanged collars around exposed ducts passing through walls, floors, or ceilings to provide finished appearance. Seal all duct joints and seams including supply, return, outside air, combustion air, relief air, ventilation air and exhaust ductwork with Hardcast Sealing System as manufactured by Hardcast, Inc., Foster, Childers, or approved equal.

C. Flexible connections of neoprene, excelon, or other NFPA approved non-inflammable fabric shall be provided in the duct system at all fan inlet and outlet connections. Flexible duct connectors shall be Durodyne or approved equal.

D. Provide cut turning vanes in all duct turns where centerline radius is located. Turning vanes shall be air-foil type with extended trailing edges. Fabricate to comply with SMACNA Sheet Metal Construction for Ventilation and Air Conditioning Systems Manual.

E. Provide duct collars and angle iron framework for mounting of automatic dampers.

F. Fabricate and support in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.

G. Construct T’s, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows are used, provide air foil turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.

H. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

I. Fabricate continuously welded round and oval duct fittings two gauges heavier than duct gauges indicated in SMACNA Standard. Joints shall be minimum 4-inch (100 mm) cemented slip joint, brazed or electric welded. Prime coat welded joints.

J. Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.

K. Fasteners: Rivets, bolts, or sheet metal screws.

L. Hanger Rods: ASTM A36 - Galvanized steel; threaded both ends, threaded one end, or continuously threaded.

2.2. DUCT SYSTEMS

A. All supply, return, exhaust, fresh air intake, relief, ventilation, outside air and combustion air ductwork shall be constructed for low pressure service (2 inch W.G.). All exposed round ductwork in finished areas shall be paintable grade, dual wall, constructed for medium pressure service (6 inch W.G.).

2.3. DUCT CONSTRUCTION

A. Rectangular and/or Round Ductwork (Low Pressure):

1. Galvanized Steel Ducts: ASTM A525 and ASTM A527 galvanized steel sheet, lock-forming quality, having G-90 Zinc coating in conformance with ASTM A90.
2. Make allowance for internal duct lining where required. Sizes shown on the drawings are inside clear dimensions.
3. Determine duct gauges for the longest duct side and use for all four sides. Joints and reinforcing requirements apply to the longest duct side.
4. Reinforce all ducts to prevent buckling, vibration, or noise as recommended in the referenced construction standards, and as required to suit the installed conditions.
5. Do not cross break duct which will receive rigid insulation covering.
6. Where tap sizes of divided-flow fittings are not indicated, make branch and main/connection sizes proportional to their respective air flows and maintain uniform transverse velocities in the fitting.
7. Make radius elbows and radius tee connection with throat radius equal to or greater than the width of the duct. Use vaned elbows where shown and where radius elbows will not fit the space, and in all square bends.
8. Turning vanes shall be the air-foil type with extended trailing edges, 36-inch maximum vane length. Where longer vanes are required, use two or more sets of vanes with intermediate runners securely fastened together.
9. Bolt, screw, rivet, or spot weld reinforcing members securely to the duct on not less than 6-inch centers.
10. Where ducts are open-ended without grilles, registers, or other means of stiffening, reinforce and stiffen the open end with standing seams or an angle frame. Provide rolled edges to prevent any exposed sharp edges.
11. Paint all cut ends on galvanized angles, rods, and other uncoated surfaces with aluminum paint.
12. Where ductwork is not painted or otherwise finished, remove all exposed traces

of joint sealers, manufacturer's identification and other markings.

13. Aluminum sheet shall be 3003 H14 alloy or duct sheet, 16,000 psi minimum tensile strength, and capable of being formed to a Pittsburgh lock seam.
14. Reinforcing members for aluminum ductwork shall be galvanized steel or aluminum unless otherwise indicated. Where aluminum reinforcing is used, size the member in accordance with ASHRAE recommendations to have rigidity equivalent to listed mild steel angle sizes.
15. Where aluminum ductwork is used, make allowance for increased thermal expansion. Particularly avoid direct contact between aluminum and concrete or masonry walls subject to dampness.
16. Determine duct gauges per SMACNA based on duct size and pressure indicated.
17. All exterior ductwork shall be single wall type with exterior field applied jacketing insulation. Inner wall shall be galvanized steel metal; outer wall shall be aluminum exterior duct insulation system as specified in Division 23 Section, “HVAC Insulation”.

B. Round and/or Rectangular Ductwork (Stainless Steel Type 316):

1. Stainless steel ducts: ASTM A167, Type 316.
2. All stainless steel ducts shall be round longitudinal seam or rectangular stainless steel Type 316. Determine duct gauges suitable for duct diameter and welded joints.
3. All dishwash machine exhaust and exhaust ductwork/dampers shall be stainless steel.
4. All longitudinal seams shall be installed with seam up.
5. These exhaust systems are low pressure service.
6. All elbows are round. Ninety degree squared elbows are not permitted.
7. All joints are welded by gas fusion using rods of similar materials.
8. All dampers, manual and motorized, shall be stainless steel Type 304.
9. These exhaust systems shall be fabricated and installed in strict accordance with requirements of SMACNA and NFPA.
10. All exterior exhaust ductwork shall be Type 316 stainless steel. Exterior rectangular exhaust ductwork shall be beveled and crossbroken for proper drainage.

C. Round Ductwork (Dual Wall - Medium Pressure)

1. Medium pressure flat oval and round ductwork shall be spiral lock-seam Type K-27 with Type P liner as manufactured by United Sheet Metal Company, Inc., Semco Manufacturing, Inc., Lindab, Ductmate, MKT Metal Manufacturing, or approved equal, Uniseal duct and Uniform fittings. Construct ductwork of galvanized sheet steel. Elbows 8 inches in diameter and smaller shall be smooth formed. Larger elbows shall be five section type. Tees and crosses and laterals shall be conical. Make joints with sleeve type couplings, short length sheet metal screws and duct sealant. Seal joints with Hardcast, Foster, Childers, or approved equal, as hereinbefore specified. Conform to duct manufacturer's recommendations for jointing and installation. Ductwork and fittings shall be manufactured by a company regularly engaged in the construction of spiral ductwork and fittings. Contractor-fabricated ductwork will not be acceptable for ductwork and fittings. Manufacturers substituted for the above specified manufacturers shall submit for approval independently published laboratory test

data on all proposed ductwork and fittings showing materials of construction, air flow, pressure drop and acoustical performance characteristics.

2. Round dual wall ductwork shall be installed to the extent shown on the drawings. All duct lining shall be provided with a perforated galvanized liner on the surface exposed to the air stream. All exposed ductwork in finished areas and where indicated on contract drawings shall be painted in color as selected by Architect. All ductwork requiring paint shall be constructed of paint grade sheet steel with paintable finish.
3. Round dual wall ductwork shall contain a 2 inch thick fiberglass insulation sandwiched between inner and outer ducts.

D. Round/Flat Oval and/or Rectangular Ductwork (Single Wall Medium Pressure):

1. Galvanized Steel Ducts: ASTM A525 and ASTM A527 galvanized medium pressure sheet steel, lock forming quality, having G90 Zinc coating in conformance with ASTM A90.
2. Determine duct gauges based on duct diameter or duct size and pressures indicated.
3. Round and flat oval duct shall be spiral seam type.
4. All branch ducts shall connect to the main duct with a 45 degree conical lateral, or low loss fittings as shown on the drawings where possible. Where not possible, a 90 degree conical connection shall be used.
5. All elbows shall be long radius.
6. All seams and joints of fittings shall be welded by gas fusion with rod material same as duct material.
7. Connections to equipment shall be flexible material, NEMA approved, having adequate reinforcing to be compatible with internal pressure of system.
8. Paint all cut ends and welded joints with aluminum paint.
9. Make allowance for internal duct lining where required. Sizes shown on the drawings are inside clear dimensions. Rectangular lined ductwork shall have perforated metal liner, similar to that hereinafter specified.
10. Determine duct gauges for the longest duct side and use for all four sides. Joints and reinforcing requirements apply to the longest duct side.
11. Reinforce all ducts to prevent buckling, vibration, or noise as recommended in the referenced construction standards and as required to suit the installed conditions.
12. Do not cross-break duct which will receive rigid insulation covering.
13. Where tap sizes of divided-flow fittings are not indicated, make branch and main connection sizes proportional to their respective air flows and maintain uniform transverse velocities in the fitting.
14. Make radius elbows and radius tee connection with throat radius equal to or greater than the width of the duct. Use vaned elbows where shown and where radius elbows will not fit the space, and in all square bends.
15. Turning vanes shall be the airfoil type with extended trailing edges, 36-inch maximum vane length. Where longer vanes are required, use two or more sets of vanes with intermediate runners securely fastened together.
16. Bolt, screw, rivet, or spotweld reinforcing members securely to the duct on not less than 6-inch centers
17. Where ducts are open-ended without grilles, registers, or other means of stiffening, reinforce and stiffen, and open end with standing seams or an angle frame.

18. Remove all exposed traces of joint sealers, manufacturer's identification and other markings.

E. Clothes Dryer Round Vent Ductwork

1. Aluminum Ducts: ASTM B209. Aluminum sheet, alloy 3003 - H14. Aluminum connectors and band stock: Alloy 6061 - T6 or of equivalent strength.
2. Dryer vent round ductwork shall be 20 gauge (minimum) aluminum construction with die-stamped or fabricated fittings. Ducts shall be constructed for low pressure operation with longitudinal seam up. Provide cleanouts at all changes in direction exceeding 45 degrees.
3. Fabricated elbows shall be the multi-piece type with each segment not exceeding 22½ degrees. Throat radius of all elbows shall equal to the duct diameter. Tees shall be the conceal type. All elbows must be smooth radius type.
4. Joints shall be the slip or flanged type. Do not use drive slip coupling bands. Make-up slip joints with duct sealer.
5. Ducts for exhausting clothes dryers shall not be assembled with screws or other fastening means that extend into the duct and that would catch lint. Install protective metal plates at wall studs where duct is installed concealed in walls.
6. Provide N.F.P.A.-90A approved and U.L. Listed flexible duct section at connection of dryer to ductwork. Also attach label to dryer vent that indicates the “equivalent length”. This warns the Owner of dryer vent equivalent length in the event they replace the dryer in the future.
7. Where clothes dryer vent ducts pass through walls, floors, or partitions, the space around the duct shall be sealed with non-combustible material and firestopped.

F. Kitchen Range Hood Exhaust Ductwork

1. Exposed Stainless Steel Ducts: ASTM A167, Type 316
2. The exhaust ductwork serving the kitchen hoods shall comply with NFPA Standard No. 96, International Mechanical Code, State of Delaware Health Department requirements, and local Health Department.
3. The exposed exhaust ductwork shall be Type 316 stainless steel (minimum 18 gauge) No. 4 finish, with all joints and seams welded, ground and polished. All welds shall be liquid tight, continuous external welds. Comply with N.S.F. requirements.
4. Concealed exhaust ductwork shall be constructed of welded carbon steel (minimum 16 gauge).
5. Proper clearance to combustibles shall be maintained as required by Code.
6. All exhaust ducts shall be installed without forming dips or traps that might collect residue. All exhaust duct must slop toward hood at .25 inches per foot. For ducts longer than 75 feet the slope shall be at least 1 inch per foot.
7. Cleanouts shall be located on horizontal sections of ducts not spaced more than 12 feet apart. Cleanouts shall also be located at all vertical risers and all changes in direction. In horizontal sections, the lower edge of the opening shall be not less than 1½ inch from the bottom of the duct. Access panels shall be of the same material and thickness as the duct. Access panels shall have a gasket or sealant that is rated for 1500 degrees F and shall be grease tight. Fasteners used to secure the access panels shall be stainless steel and shall not penetrate duct walls. A sign shall be placed on all access panels stating: ACCESS PANEL - DO NOT OBSTRUCT.

8. Dampers, either manual or automatic, shall not be installed in kitchen hood exhaust ducts or kitchen hood exhaust duct systems.
9. Ducts that terminate above the roof shall have the discharge located a minimum of 40 inches above the roof surface.
10. Utilize light to verify that all joints are sealed. Submit results of light testing with minimum 100 watt light bulb.

2.4. DISHWASHER EXHAUST DUCTWORK

A. Aluminum Ducts: ASTM B209, aluminum sheet, alloy 3003-H14. Aluminum connectors and bar stock: Alloy 6061-T6, or of equivalent strength stainless steel ducts: ASTM A167, Type 316.

B. Ductwork shall be 20 gauge aluminum construction where concealed and 18 gauge Type 316 stainless steel where exposed.

C. Ducts shall be constructed for low pressure operation with all seams liquid tight.

D. Ductwork shall be pitched ¼ inch per foot back to hood or equipment for drainage.

E. Provide a cleanout door of the same material as the ductwork for inspection and cleaning of interior duct surface. Cleanout shall be located in the vertical riser. Label all duct cleanout doors.

2.5. WATER HEATER INTAKE AND WATER HEATER EXHAUST DUCTWORK (PIPING) MATERIAL

A. Water Heater Exhaust Piping-CPVC Pressure Pipe: ASTM F 441/F441M, solid-wall pipe.

1. CPVC Socket Fittings: ASTM F 441/F441M pipe, socket type, and ASTM F438 socket type fitting.
2. Joints: Solvent weld with solvent cement.
3. Furnish and install roof curbs and roof terminations.
4. Use CPVC solvent cement that has a VOC content of 490 g/l or less when calculated to 40 CFR 59, subpart D (EPA method 24).
5. Use CPVC primer that has a VOC content of 550 g/l or less when calculated to 40 CFR 59, subpart D (EPA method 24).
6. Install lime chip neutralizer kit at all flue (exhaust) drain lines prior to discharge into floor drain. Condensate neutralizer shall be as manufactured by JJM Boiler Works or approved equal.

B. Water Heater Intake Piping – PVC Pressure Pipe: ASTM D2665, solid wall drain, waste and vent (schedule 40).

1. PVC Socket Fittings: Schedule 40 PVC, ASTM F89 socket fittings.
2. Joints: Solvent weld with solvent cement.
3. Use PVC solvent cement that has a VOC content of 510 g/L of less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
4. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

5. Water heater intake ductwork shall be PVC.

2.6. AIR TRANSFER OPENINGS

A. Furnish and install metal sleeves or frames, of the same material as the duct or air terminals attached thereto, in all air transfer openings through walls, partitions, floors and other building construction, extending completely through the opening. Securely fasten the sleeves or frames in place and provide face flanges on both sides. Where grilles or registers are required, attach them to the sleeve or frame, or extend ductwork where shown on the drawings. If no grilles, registers or duct connections are required, furnish and install ½ inch x ½ inch removable galvanized wire mesh on one face.

2.7. AIR VOLUME CONTROLS

A. Furnish and install air volume control devices where indicated and where required to adjust and balance air flow in the systems, whether indicated or not. Volume dampers shall be provided in all branch ducts serving air outlets and inlets. For existing air devices install a new volume damper and where required for access, a new access door to allow access and adjustment.

B. Air extraction for air outlets and branch ducts shall be the gang-operated vane type, Tuttle & Bailey - Vectrol, Type VLC or VLK as appropriate, or approved equal, with suitable adjusting device and means of access.

C. Manual volume dampers in ductwork shall be factory-assembled units with rigid frame, opposed-blade action, and locking quadrant operator. Mark the extended damper shaft and align the operating handle to indicate the blade position. Dampers shall be as manufactured by Ruskin, American Warming and Ventilating, Inc., Arrow, Vent Products Company, or approved equal. Rectangular dampers shall be Type MD35, with steel channel frame, 16 gauge steel blades, 9 inch maximum blade spacing, low pressure, nylon bearings, galvanized finish with aluminum paint touch up. Round manual balancing dampers shall be Type MDRS25 manufactured by Ruskin, Arrow, American Warming and Ventilating, Inc., or as approved equal. When external insulation is to be applied, provide sheet metal standoffs on all manual volume dampers. Provide blade stops to minimize air gaps around damper blades when closed.

D. Motor-operated dampers shall be as hereinafter specified under Division 23 Section, “Instrumentation and Controls of HVAC & Plumbing System”.

E. Duct turning vanes shall be Tuttle & Bailey Ducturns, or approved equal.

F. Furnish and install duct collars and angle iron frames for the installation of ATC dampers.

G. Provide Type 316 stainless steel motor-operated dampers for installation in stainless steel ductwork.

H. Where volume dampers are installed in exposed finished spaces locate damper handle on top of duct.

I. Where volume dampers are installed above ceilings attach a colored piece of tape so that

Test and Balance Engineer can easily locate for air flow adjustment.

2.8. REMOTE MANUAL VOLUME DAMPER CABLE OPERATORS

A. Available manufacturers offering products that may be incorporated into the work include but are not limited to the following:

1. Young Regulator
2. Cesco Products
3. Pottorff
4. Ruskin

B. Description: Cable system designed for remote manual damper adjustment.

C. Tubing: Brass , Copper , or]Aluminum.

D. Cable: Stainless Steel.

E. Wall-Box Mounting: Recessed.

F. Wall-Box Cover-Plate Material: Steel.

G. Where volume dampers are located above hard ceilings, furnish and install remote manual volume damper cable operators.

2.9. INSTRUMENT TEST PORTS

A. Furnish and install instrument test ports in the ductwork to allow use of pitot tube length. Equip holes with Ventlok #699 instrument ports. Fittings shall extend beyond duct covering and insulation.

B. Kitchen hood grease ducts shall be fitted with metal to metal seals for pitot tube access port. Assembly shall consist of stainless steel bolt, toothed lock washer, and nut. Nut shall be welded to grease duct as indicated on contract drawings. Locations of pitot tube access ports shall be coordinated with Test and Balance Engineer prior to installation of the ports.

2.10. DUCT THERMOMETERS

A. Duct thermometers shall be Dresser Industries, Trerice, Weiss, Weksler, Miljoco, or approved equal direct-mounting filled system dial thermometers. Duct thermometers shall be vapor-actuated, universal-angle dial type, cast aluminum case with 4 ½ inch diameter, glass lens. Duct thermometers shall include adjustable joint with finish to match case, 180 degree adjustment in vertical plane, 360 degree adjustment in horizontal place, with locking device. Thermal bulbs shall be copper with phosphor-bronze bourden pressure tube. Movement shall be brass, precision geared. Duct thermometer scales shall be Progressive, satin-faced non-reflective aluminum with permanently etched markings. Each stem shall be copper-plated aluminum or brass for separable socket of length to suit installation.

B. Where ductwork is installed at a height that would require duct thermometers to be installed 10 feet above finished floor or greater then remote-ready filled - system dial thermometers shall be installed. Connecting tubing shall be bronze, double-braided, armor-over-copper capillary; of length to suite installation.

C. Duct thermometers shall be furnished and installed at rooftop geothermal units, energy recovery ventilators, heat pumps, water source heat pump units, and kitchen make-up air units as follows:

LOCATION	RANGE
Outdoor Air Duct	-40 degrees Fahrenheit to 120 degrees Fahrenheit
Return Air Duct	40 degrees Fahrenheit to 180 degrees Fahrenheit
Mixed Air Plenum	30 degrees Fahrenheit to 180 degrees Fahrenheit
Supply Air Duct	30 degrees Fahrenheit to 180 degrees Fahrenheit
Exhaust Air Duct	30 degrees Fahrenheit to 180 degrees Fahrenheit

D. Description: Flanged fitting bracket for mounting in hole of duct, with threaded end for attaching thermometer.

1. Extension Neck Length: Nominal thickness of 2 inches, but not less than thickness of exterior insulation.
2. Insertion Neck Length: Nominal thickness of 2 inches, but not less than thickness of insulation lining.

2.11. FIRE DAMPERS

A. Furnish and install automatic fire dampers where indicated, in all 2-hour fire-rated partitions, shafts, slabs, etc., and where required by NFPA Standard No. 90A and by the Fire Marshal. Refer to the architectural drawings for location of all fire-rated walls, shafts and slabs. Fire Dampers shall also be provided at all transfer air devices installed in rated walls at all floor penetrations, and as shown on the contract drawings.

B. Construction of fire dampers shall conform to requirements of NFPA No. 90A, UL Standard 555 and shall bear UL label. Fire dampers shall be set in frames adequately secured to fire partitions, floors, etc., and installed in strict accordance with UL listing and manufacturer's instructions.

C. Fire damper shall be Dynamic Type for rectangular ductwork and round ductwork as manufactured by Ruskin, Air Balance, Inc., Arrow, Greenheck, Lloyd Industries, Nailor, Vent Products Company, or approved equal, multi-leaf accordion type, held open by adequate heavy gauge wires and suitably calibrated fusible links. Vertical dampers (horizontal air flow) shall close by gravity. Horizontal dampers (vertical air flow) shall be closed by suitable and positive spring closing devices.

D. Damper frames shall provide pocket which shall store the damper leaves in open position outside of the air stream and shall provide for 100 percent opening connecting to ductwork or grille face. Damper material shall match connecting ductwork.

E. Provide adequately sized hinged access doors with cam locks for access to all fusible links and for resetting fire dampers. Where applicable, access to fire dampers shall be through registers or grilles. Provide identification on access door indicating fire damper within. Letters shall be not less than ½-inch in height.

F. Submit complete information to the Engineer including installation details. Furnish and install sleeves, angles, break-away duct connections, per UL listing.

G. Furnish to the Owner in a suitable storage container not less than six (6) fusible links of each type, size, and rating used on the project. Where required, furnish Greenheck Type CR, CO, or Type C transition sleeves.

H. For corrosive environments fire dampers shall be Type 304 stainless steel including sleeves and angles.

2.12. DUCT ACCESS DOORS

A. Furnish and install adequately sized duct access doors at fire dampers, air measuring devices, motor-operated dampers, duct smoke detectors, duct coils and other locations where indicated and required for duct access. Doors shall be the continuous piano-hinged type with approved latches and neoprene compression-type gaskets with 1 inch thick fiberglass double skin and shall be Ruskin Model ADH22, Air Balance, Inc., FSA-100 or as approved equal. Stiffen ductwork at door openings. Where doors are installed in insulated ductwork, provide equivalent insulation in the door assembly. Where access doors are installed in the fire-rated partitions, provide Fire Seal access doors as manufactured by Air Balance, Inc., or approved equal, UL approved, meeting the rating of the enclosure in which the access door is installed.

B. Where duct access doors are installed in medium pressure ductwork, they shall be as manufactured by Ruskin, Type ADHP-3, or approved equal, with six latches continuous gasket and insulated core.

C. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

2.13. SPIN-IN FITTINGS

A. Furnish and install spin-in fittings where indicated on the contract drawings, Model SM-20G, as manufactured by General Environment Corporation, or an approved equal.

2.14. DUCT LINING (LOW PRESSURE DUCTWORK)

A. All low pressure supply and return ductwork within 10 feet of air handling units, rooftop units, kitchen make-up air units, energy recovery ventilation units, geothermal heat pump units, and as additionally shown on Contract Drawings, shall be lined on the interior for sound attenuation and thermal insulation.

B. All low pressure ductwork within 10 feet of return or exhaust air fans and as additionally shown on Contract Drawings shall be lined on the interior for sound attenuation and thermal insulation. (Does not apply to Kitchen Hood Exhaust Fans)

C. All internal duct lining for low pressure duct systems shall be provided with an interior galvanized perforated liner.

D. Provide additional exterior insulation where required and as indicated in Division 23 Section, "HVAC Insulation".

E. The lining insulation shall be 1 inch thick, 3.0 pcf density, Aeroflex plus Duct Liner Type 300, Owens Corning Quiet R Rotary Duct Liner, Manville, Knauf, or approved equal. The material shall be specifically designed for this application, shall have a black, fire-resistant coating, shall meet NFPA Standards 90A and 90B and shall have a UL Fire Hazard Classification of Flame Spread 25 or less and smoke developed of 10 or less. The black-coated surface shall face the air stream.

F. All exposed edges and the leading edge of all cross joints of the liner shall be coated with the same adhesive used to secure the duct liner to metal surface. All air stream surfaces shall be treated with EPA registered fungicide Foster 40-20. Coating shall meet ASTM D 5590 with 0 growth rating.

G. The duct liner shall be adhered to the metal with 100 percent coverage of adhesive. Adhesive shall conform to Adhesive and Sealant Council Standards for adhesives for duct liner; ASTM C916, Type II (ASC-A-7001-A-1971). Adhesive shall be Foster 85-60, Childers CP-127 or approved equal.

H. The duct liner shall be additionally secured with mechanical fasteners, which shall compress the duct liner sufficiently to hold it firmly in place. Mechanical fasteners shall conform to Mechanical Fastener Standard MF-1-1971, available from Sheet Metal and Air Conditioning Contractors National Association.

I. All duct lining shall be installed in complete accordance with the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Duct Liner Application Standard, First Edition and Green Guard Indoor Air Quality certification program requirements.

J. Dimensions on drawings indicate inside clear opening of rectangular ductwork. Increase duct dimensions 2 inches each way for accommodating insulation on all shop or field-fabricated rectangular ductwork where lining is specified.

2.15. DUCT LINING (MEDIUM PRESSURE DUCTWORK)

A. All medium pressure supply and return ductwork within 10 feet of air handling units, rooftop units, kitchen make-up air units, geothermal heat pumps, energy recovery ventilators, ERV unit, and exhaust ducts and as additional shown on contract drawings shall be lined on the interior for sound attenuation and thermal insulation.

B. All medium pressure ductwork within 10 feet of return or exhaust air fans and as shown on Contract Drawings shall be lined on the interior for sound attenuation and thermal insulation.

C. Provide additional exterior insulation where required and as indicated in Division 23 Section, "HVAC Insulation".

D. All internal duct lining for medium pressure duct systems shall be provided with interior galvanized perforated liner.

E. The insulation shall be 1 inch thick, 3.0 pcf density, Aeroflex plus Duct Liner Type 300, Owens Corning Quiet R Rotary Duct Lines, Manville, Knauf, or approved equal. The material shall be specifically designed for this application, shall have a black, fire-resistant coating, shall meet NFPA Standards 90A and 90B and shall have a UL Fire Hazard Classification of Flame Spread 25 or less and smoke developed of 10 or less. The black-coated surface shall face the air stream.

F. All exposed edges and the leading edge of all cross joints of the liner shall be coated with the same adhesive used to secure the duct liner to metal surface. All air stream surfaces shall be treated with EPA registered fungicide Foster 40-20. Coating shall meet ASTM D5590 with 0 growth rating.

G. The duct liner shall be adhered to the metal with 100 percent coverage of adhesive. Adhesive shall conform to Adhesive and Sealant Council Standards for adhesives for duct liner; ASTM C 916 (ASC-A-7001-A-1971). Adhesive shall be Foster 85-60, Childers CP-127 or approved equal.

H. The duct liner shall be additionally secured with mechanical fasteners which shall compress the duct lines sufficiently to hold it firmly in place. Mechanical fasteners shall conform to Mechanical Fastener Standard MF-1-1971, available from Sheet Metal and Air Conditioning Contractors National Association.

I. All duct lining shall be installed in complete accordance with the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Duct Liner Application Standard, First Edition and Green Guard Indoor Air Quality certification program requirements.

J. Dimensions on drawings indicate inside clear opening of rectangular ductwork. Increase duct dimensions 2 inches each way for accommodating insulation on all shop or field-fabricated rectangular ductwork where lining is specified.

2.16. AIR DEVICE REQUIREMENTS

A. Furnish and install air supply, return, exhaust devices of sizes and capacities as scheduled on the drawings. Catalog numbers shown are Titus, Inc., products for equipment which have been found suitable for the application. Other manufacturers listed below or approved equal will be considered only if performance characteristics including throw, drop, pressure loss, sound pressure level, etc., are equal to or better than the performance characteristics of the specified products. All air devices shall be ADC certified. Ductwork behind registers, grilles, open ended ducts, and diffusers shall be given two coats of flat black paint. Perimeter of all ceiling diffusers shall be caulked to provide a neat, aesthetic appearance.

B. Where air terminal devices are installed in duct collars or branches, furnish and install air extractors. Furnish and install control grids, volume dampers, and/or other accessories necessary to ensure uniform air flow across the terminal devices. Accessories shall be of the same material as the terminal device. Install fixed blade terminals so that blades block the normal line of vision. Furnish three (3) of each type of removable key operators.

C. Contractor shall determine frame and mounting type as per type of ceiling as shown on Architectural drawings.

D. Air devices and accessories that are installed in a finished, non-white ceiling shall be of a color as selected by the Architect.

E. Noise Criteria: All air devices shall be sized and selected to limit maximum NC (Noise Criteria) levels to 30.

2.17. SUPPLY AIR DEVICES

A. RD1 Diffuser, Round

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Titus Model TMRA
b. Metal-Aire
c. Price
d. Tuttle & Bailey
e. Anemostat
f. Carnes
g. Nailor
h. Krueger

2. Construction:

a.	Material:	Steel Aluminum
b.	Finish:	Baked Enamel, White
c.	Face Style:	Four Cone
d.	Mounting:	Duct Connection
e.	Pattern:	Fully Adjustable
f.	Damper:	Integral, Opposed Blade type

3. Accessories:

a. Equalizing grid
b. Safety Chain

4. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

B. SD1 Diffuser, Square/Rectangular

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Titus Model TDCA-AA
b. Metal-Aire

c. Price
d. Tuttle & Bailey
e. Anemostat
f. Carnes
g. Nailor
h. Krueger

2. Construction:

a. Material: Aluminum
b. Finish: Baked Enamel, White when installed in white ceiling or baked enamel, color selected by Architect when installed in non-white ceilings
c. Face Style: Louvered
d. Mounting: Lay-in or Gypboard
e. Pattern: Adjustable core style
f. Damper: Integral, Opposed Blade type

3. Accessories:

a. Square to round neck adaptor
b. Adjustable pattern vanes

4. Provide auxiliary panel for lay-in tile installation.
5. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

C. SD2 Diffuser, Perforated

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Titus Model PAR-AA
b. Metal-Aire
c. Price
d. Tuttle & Bailey
e. Anemostat
f. Carnes
g. Nailor
h. Krueger

2. Construction:

a. Material: Aluminum
b. Finish: Baked Enamel, White when installed in white ceiling or baked enamel, color selected by Architect when installed in non-white ceilings
c. Face Style: Perforated
d. Mounting: Lay-in or Gypboard
e. Pattern: Straight Down
f. Damper: Opposed Blade type

3. Accessories:

    a. Square to round neck adaptor

4. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

D. SG1 Grille, Square/Rectangular

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Titus Model 300FS
    b. Metal-Aire
    c. Price
    d. Tuttle & Bailey
    e. Anemostat
    f. Carnes
    g. Nailor
    h. Krueger

2. Construction:

    a. Material: Aluminum
    b. Finish: Baked Enamel, White when installed in white ceiling or baked enamel, color selected by Architect when installed in non-white ceilings
    c. Face Style: Grille
    d. Mounting: Surface
    e. Pattern: Double Deflection; spaced 3/4 inch apart.
    f. Damper: Integral, Opposed Blade type

3. Accessories:

    a. Drop control

4. The grille shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

2.18. RETURN/EXHAUST/TRANSFER GRILLES

A. RG1 Return/Exhaust/Transfer Grille, Square/Rectangular

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Titus Model 350FS
    b. Metal-Aire
    c. Price
    d. Tuttle & Bailey
    e. Anemostat
    f. Carnes

g. Nailor
h. Krueger

2. Construction:

a.	Material:	Aluminum
b.	Finish:	White Baked Enamel
c.	Ceiling Type:	Lay-in, Gypboard, Sidewall
d.	Blades:	Fixed, 35° Angle, 3/4” Spacing

3. Accessories:

a.	Face:	Grille
b.	Damper:	Integral, Opposed Blade type

4. Provide auxiliary panel for lay-in tile installation.
5. The register shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

B. RG2 Return/Exhaust/Transfer Grille, Square/Rectangular with Filter, Aluminum

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Titus Model 350FSF
b. Metal-Aire
c. Price
d. Tuttle & Bailey
e. Anemostat
f. Carnes
g. Nailor
h. Krueger

2. Construction:

a.	Material:	Aluminum
b.	Finish:	White Baked Enamel
c.	Ceiling Type:	Lay-in, Gypboard, Sidewall
d.	Blades:	Fixed, 35° Angle, 3/4” Spacing

3. Accessories:

a.	Face:	Grille
b.	Damper:	Integral, Opposed Blade type

4. Provide auxiliary panel for lay-in tile installation.
5. Provide return air filter racks and 1” thick filters. (Furnish spare filter with each air device.)
6. The register shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

C. RG3 Return/Exhaust/Transfer Grille, Square/Rectangular with Filter, Steel

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Titus Model 350RSF
   b. Metal-Aire
   c. Price
   d. Tuttle & Bailey
   e. Anemostat
   f. Carnes
   g. Nailor
   h. Krueger

2. Construction:

   a. Material: Steel, 16 gauge
   b. Finish: White Baked Enamel
   c. Ceiling Type: Sidewall
   d. Blades: Fixed, 35° Angle, 3/4” Spacing

3. Accessories:

   a. Face: Grille
   b. Damper: Integral, Opposed Blade type
   c. Core: Hinged

4. Provide return air filter racks and 1” thick filters. (Furnish spare filter with each air device.)
5. The register shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.
6. Noise Criteria: All air devices shall be sized and selected to limit maximum NC (noise criteria) levels to 30.

2.19. LOUVERS (FIXED BLADE)

A. Furnish and install wall louvers of the size and capacity shown on the contract drawings. Louvers shall be Greenheck Model EHV-901 (high velocity wind driven rain) heavy gauge extruded aluminum stationary type louvers, Vent Projects Company, or approved equal. Louvers shall be stationary, dual module type consisting of a “front” louver with J-style blades and a “rear” louver with vertical rain resistant style blades. Louver frame shall be a total depth of 9 inches.

B. Front louvers shall be drainable type fabricated from heavy gauge 6063-T5 aluminum extrusions of .081 inch nominal wall thickness. Blades shall be positioned at 37 degree and 45 degree angles, approximately 4.25 inches on centers. Rear louver shall b vertical rain resistant style, heavy gauge extruded 6063-T5 aluminum, 0.060 nominal thickness, positioned on approximately 1.5 inch blade spacing. Each louver shall be equipped with a frame and removable rear-mounted screen of flattened aluminum. Each factory assembled louver section shall be designed to withstand wind loadings of 25 psf. Louvers too large for complete factory assembly shall be built up by the installing contractor from factory assembled louver sections.

C. Louvers shall be tested in accordance with AMCA 550-L, AMCA-540, and AMCA 550 (Certified High Velocity, Rain Resistant, and Impact Resistant Louver).

D. Louvers shall be supplied with a factory Kynar finish applied after a thorough cleaning and preparation of the metal surface. A total dry film thickness of approximately 1.2 mils shall be provided. Custom color shall be as selected by Architect.

E. Louvers shall be provided with ¼ inch x ¼ inch aluminum bird screens, factory-furnished and installed. Louver performance data shall be A.M.C.A. certified. All louvers shall be caulked weathertight around entire perimeter.

2.20. LOUVER BLANK-OFF PANELS

A. Insulated, Blank-Off Panels: Laminated panels consisting of insulating core surfaced on back and front with metal sheets and attached to back of louver

1. Thickness: 2 inches (50mm)
2. Metal Facing Sheets: Aluminum sheet, not less than .032 inch (.81mm) nominal thickness.
3. Insulating Core: Rigid, glass-fiber-board insulation or extruded-polystyrene foam
4. Edge Treatment: Trim perimeter edges of blank-off panels with louver manufacturer’s standard extruded-aluminum-channel frames, not less than .080 inch (2.03mm) nominal thickness with corners mitered and with same finish as panels.
5. Seal perimeter joints between panel faces and louver frames with gaskets or sealant.
6. Panel Finish: Same finish applied to louvers.
7. Attach blank-off panels with stainless steel sheet metal screws.
8. Cover all unused openings in louvers.

2.21. INTAKE/RELIEF HOODS

A. Furnish and install heavy gauge aluminum intake/relief hoods of size, capacity, and arrangement as shown on Contract Drawings. Intake/relief hoods shall be Greenheck Model FHI for intake or Model FHR for relief as manufactured by Greenheck, ACME Engineering, Cook, Twin City, Vent Products Company, or approved equal.

B. Gravity roof ventilators shall be constructed of heavy gauge aluminum or galvanized steel. Hoods shall be constructed of precision formed, arched panels with interlocking seams. Bases shall be constructed so that the curb cap is 8 inches larger than the throat size. Insulated roof curbs shall be furnished as specified and shall be of same manufacturer as roof hood.

C. Hood support members shall be constructed of galvanized steel and fastened so that the hood can be either removed completely from the base or hinged open. Birdscreens constructed of ½ inch galvanized steel mesh shall be mounted horizontally across the intake/discharge area of the hood. Intake units with throat widths through 42 inches shall ship assembled when throat lengths do not exceed 84 inches. Relief units with throat widths through 48 inches shall ship assembled when throat lengths do not exceed 96 inches.

D. Motor-operated dampers shall be provided by the ATC Subcontractor and installed by Mechanical Contractor.

2.22. OPEN END DUCTS (OED)

A. Whether indicated on plans or not, all open-ended ducts shall be provided with a protective screen.

B. All open-ended ducts shall be furnished with a 12 gauge ½ inch x ½ inch aluminum mesh screen. Screens shall be permanently installed in a removable frame, and the frame shall be attached to the open-ended duct in a neat, workmanship-like manner without any exposed edges or sharp surfaces.

C. Screen shall be attached to a ¾ inch x 1/8 inch continuous galvanized perimeter frame. Install duct stiffeners greater than 16 inches in any direction at open-ended ducts.

D. Behind all open end ducts, paint ductwork and dampers with two (2) coats of flat black paint.

2.23. DRIP PANS

A. Furnish and install suitable watertight, aluminum drip pans where water or drain piping is routed over electrical switchgear, transformers, computers, elevator machine equipment, dry storage rooms, etc. Each drip pan shall have a 1 inch copper type M drain piped to discharge where shown on drawings; or, if not shown, to discharge over nearest available open drain. Size and arrangement shall be as approved by Engineer. Sides shall be minimum 1.5 inches deep.

B. Drain pans shall be of 16 gauge welded construction. Provide drawings of typical drain pan construction for approval before construction. See Submittals in Division 01 Section, "Product Requirements".

2.24. DUCT SEALANTS AND ADHESIVES

A. All ductwork shall be sealed, including low pressure exhaust systems. Transverse joints and longitudinal seams in duct systems shall be sealed with a duct sealant of the type specified hereinafter in Section 1, 2, or 3, or with a tape sealing system as specified in Section 4. Spiral lockseams are not longitudinal seams and do not require duct sealant. All seams and joints shall require duct sealant suitable for the pressure rating and installation application. All sealants shall exceed 500 hours without becoming brittle under ASTM-D572 test conditions (oxygen bomb), unless specified otherwise. No surface preparation or solvent cleaning shall be necessary to remove light coatings of oil and dust before applying sealant unless specified otherwise. Flanged joints shall be sealed according to Section 5. Construction joints that are not fully welded shall be sealed according to Section 6. Adhesive to secure insulation to metal surfaces shall be that specified in Section 7.

1. Assembly joints to be installed indoors or outdoors shall be sealed with Foster

32-19, Childers CP-146, United Duct Sealer WB, or equivalent, which is a water-based sealant formulated to withstand service temperatures from 20 degrees F to +200 degrees F. Sealant shall have a UL Classification marking with a flame spread of 15 and smoke developed of 0 when applied to inorganic reinforced cement board, both at a coverage of 31 square feet per gallon. Store and apply between 40°F (4°C) and 100°F (38°C); protect from freezing.

2. Assembly joints to be installed indoors shall be sealed with Foster 32-19, childers CP-146, UNI-GRIP™ duct sealer or equivalent, which is a water-based (vinyl-acrylic polymer) sealant formulated to withstand temperatures from –20 degrees to +200 degrees Fahrenheit. Surfaces to be sealed should be clean, dry, and free from oil, grease, and dirt. Sealant shall be nonflammable (wet) and fire retardant. Sealant shall have a UL Classification marking with a flame spread of 5 and smoke developed of 5 when applied to 18-gauge galvanized steel and a flame spread of 0 and smoke developed of 0 when applied to inorganic reinforced cement board, both at a coverage of 40 square feet per gallon.
3. Assembly joints shall be sealed with UNI-CAST® tape sealing system or equivalent, which is a combination of an adhesive activator and woven-fiber tape impregnated with a gypsum mineral compound. Modified acrylic/silicone activator (MTA-20 for indoor use) reacts exothermically with the tape to form a hard, airtight seal. Sealant shall be formulated to withstand temperatures from –40 degrees F to +200 degrees Fahrenheit. Combination of tape and MTA-20 adhesive shall have a flame spread and smoke developed of 0. Do not use for outdoors.
4. Flanged joints to be installed indoors shall be sealed with UNI-GASKET™ flange sealer or equivalent, which has a synthetic elastomer base and is formulated to withstand temperatures from –20 degrees F to +150 degrees F. Sealant shall have a UL Classification marking with a flame spread of 5 and smoke developed of 5 when applied to 18-gauge galvanized steel and a flame spread of 0 and smoke developed of 5 when applied to inorganic reinforced cement board, both at a coverage of 80 square feet per gallon.
5. Where duct fittings are constructed with standing seam or spot-welded techniques, all construction joints shall be sealed with UNI-WELD™ metal cement or equivalent, which is composed of neoprene rubber, resins, and inert reinforcing material dispersed in a petroleum distillate. Sealant shall be formulated to withstand temperatures from –20 degrees F to +225 degrees F. Sealant shall have a UL Classification marking with a flame spread of 0 and smoke developed of 0 when applied to 18-gauge galvanized steel and a flame spread of 0 and smoke developed of 0 when applied to inorganic reinforced cement board, tested as applied in two 1/8 inch beads 8 inches on center.
6. Where insulation is to be secured to metal surfaces, the adhesive used shall be Foster 85-60, Childers CP-127, UNI-TACK™ duct liner adhesive or equivalent, which are water-based, vinyl-acrylic copolymer adhesives formulated to withstand temperatures from –20 degrees Fahrenheit to +200 degrees Fahrenheit. Adhesive shall have a UL Classification marking with a flame spread of 0 and smoke developed of 0 when applied to 18-gauge galvanized steel and a flame spread of 0 and smoke developed of 0 when applied to inorganic reinforced cement board, both at a coverage of 267 square feet per gallon. Adhesive shall conform to ASTM C916, Type II.

B. Manufacturers: Duct Mate, United McGill, MKT Metal Manufacturers, Semco, Elgen, Childers, Foster, or as approved equal.

2.25. AUXILIARY DRIP PANS

A. Furnish and install suitable watertight, aluminum drip pans for all suspended air handling units, heat pumps, or air handling units installed on upper floor and/or attic. Each drip pan shall have a 1" copper type "M" drain piped to discharge where shown on drawings. Drain pan shall extend 3" beyond sides of air handling unit/heat pump. Sides shall be minimum 1.5" deep.

B. Drain pans shall be of 16 gauge welded construction. Provide drawings of typical drain pan construction for approval before construction. See Submittals, Division 23 Section, “Common Work Results for HVAC” and Division 01, Section, “General Requirements”.

C. Install U.L. 580 listed condensate float switch in auxiliary drain pan and wire to shut-down unit upon sensing water. All control and interlock wiring to be furnished and installed under Division 23 Section, “Instrumentation & Controls of HVAC & Plumbing Systems”

2.26. FILTER MEDIA DURING CONSTRUCTION

A. Filter media installed during construction: Minimum MERV 8.

PART 3. EXECUTION

3.1. DUCT INSTALLATION REQUIREMENTS

A. Coordinate ductwork with other work and install ducts at proper elevations and locations to maintain indicated ceiling heights and clearances. Provide all elbows, transitions, offsets, connections, and other fittings necessary to fit the work into place or to connect to equipment or diffusers. Method of duct support connection to structure and slabs shall be approved by Structural Engineer, and Shop Drawings shall be submitted.

B. Substantially support ductwork with structural shapes, flat bars, or formed strap hangers securely attached to the building structure by means of bolts, clamps, or inserts. Support vertical ducts by angles attached to the duct and resting on the floor or supported by brackets or hangers attached to the building structure. Strap hangers shall be 16-gauge minimum galvanized steel formed under the bottom edge of duct. Use square ¼ inch thick washers tight against the bend on upper strap attachments to horizontal surfaces. Place all supports external to the ductwork and out of the air stream. Provide additional supports at coils and other concentrated loads. Arrange supports so that duct weight is not transmitted to ceilings, fans or other equipment.

C. Prevent direct contact between ductwork and building surfaces or other equipment. Where ducts pass through walls, partitions, floors, ceilings, or roofs, pack and seal the space around the duct with an approved fire-safe inert material. Provide flanged duct escutcheons at all exposed ducts that pass through walls, partitions, floors, and ceilings.

D. Use galvanized (compatible) corrosion-resistant hangers, supports, brackets, and hardware. All duct supports in corrosive or wet areas shall be provided with noncorrosive metal finish such as Galv-Krom or equal.

E. Furnish and install NFPA-approved duct connections where shown and at all connections to fans, air handling units, and similar rotating equipment. Use glass-reinforced neoprene fabric, roll-formed to sheet metal strips or flanges. Support adjacent ductwork to provide sufficient slack in the connection. For corrosive or chemical fume duct systems utilize chemical resistant flexible connections.

F. See NFPA 90A, and latest publication of SMACNA. Prevent direct contact between ductwork and building surfaces or other equipment. The opening in the construction around the duct shall not exceed one-inch average clearance on all sides. Where ducts pass through walls, partitions, floors, ceilings, or roofs, pack and seal the space around the duct with an approved fire-safe inert material capable of preventing the passage of flame and hot gases sufficiently to ignite cotton waste when subjected to the same NFPA 251 Time-Temperature Conditions required for fire barrier penetration. All exposed duct penetrations shall be finished with a sheet metal field erected flange escutcheon to form a neat appearance.

G. Coordinate duct installation with the requirements of Division 23 Section, “Vibration Controls for HVAC, Plumbing & Fire Protection Equipment”.

H. Install in accordance with manufacturer’s instructions.

I. Install and seal ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.

J. Duct Sizes are inside clear dimensions. For lined ducts, maintain sizes inside lining.

K. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

L. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

M. Use crimp joints, with or without bead, for joining round duct sizes eight (8) inches and smaller with crimp in direction of air flow.

N. Use double nuts and lock washers on threaded rod supports.

O. Set plenum doors 6 to 12 inches (150 to 300 mm) above floor. Arrange door swings so that fan static pressure holds door in closed position.

P. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for clean out. Use welded stainless steel for ductwork exposed to view and welded carbon steel for ducts where concealed. Submit to local Health Department calculations, duct layout, hood layout, sizes for all kitchen hood exhaust, make-up air systems prior to fabrication.

Q. During construction, provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork systems. Also provide temporary closures of metal or taped polyethylene at all air handling equipment openings to prevent dust from entering equipment openings.

R. Paint behind all air devices, louvers, and open end ducts with 2 coats of flat black paint.

3.2. ACCESSORY INSTALLATION REQUIREMENTS

A. Install accessories in accordance with manufacturer's instruction, NFPA 90A, and SMACNA HVAC Duct Construction Standards - Metal and Flexible. Also provide temporary closures of metal or taped polyethylene at all air handling equipment openings to prevent dust from entering equipment openings.

B. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, duct detectors, air flow monitoring stations, duct-mounted equipment, and elsewhere as indicated. Provide for cleaning kitchen exhaust ductwork in accordance with NFPA 96. Provide minimum 10 x 10 inch size for hand access, 18 x 18 inch size for shoulder access 20 x 20 inch for kitchen exhaust systems. Review locations prior to fabrication.

C. Provide duct test holes where required for testing and balancing purposes. Review locations with Test and Balance Engineer prior to installation.

D. For all motor operated dampers, mark the shaft so operators know the position of the damper.

E. Provide fire dampers at locations indicated, where ducts and outlets pass through fire-rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion-resistant springs, bearings, bushings and hinges.

F. Demonstrate re-setting of fire dampers to Owner's representative.

G. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment and supported by vibration isolators. Refer to Division 23 Section, "Vibration Control for HVAC and Plumbing Systems".

H. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum duct widths from duct take-off.

I. Use splitter dampers only where indicated.

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

K. Install diffusers, registers, and grilles to ductwork with airtight construction.

L. Check location of all air outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangements.

M. Install duct thermometer support flanges in wall of duct. Attach to duct with screws. Locate duct mounted thermometers, minimum 10 feet downstream of mixing dampers, coils or other devices causing air turbulence.

N. Install remote - reading duct dial thermometers in control panels with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length. Mount control panel 60 inches above finished floor and label each dial thermometer.

O. Install duct accessories according to applicable details shown in SMACNA's HVAC Duct Construction Standards Metal and Flexible for metal ducts.

P. Install volume dampers in lined duct; avoid damage to and erosion of duct liner.

Q. Provide test holes at fan inlet and outlet and elsewhere as indicated.

R. Install fire dampers according to manufacturer's UL approved written instructions.

1. Install fusible links in fire dampers. Label access doors according to equipment served.

S. Adjust duct accessories for proper settings.

T. Adjust fire dampers for proper action.

3.3. DUCT LINING INSTALLATION REQUIREMENTS

A. All portions of duct designated to receive duct liner shall be completely covered with duct liner. Transverse joints shall be neatly butted and there shall be no interruptions or gaps. The black pigmented or mat faced surface of the duct liner shall face the airstream.

B. Duct liner shall be adhered to the sheet metal. with 90 percent coverage of adhesive complying with requirements of ASTM C916. All exposed leading edges and transverse joints shall be factory coated or coated with adhesive during fabrication. Install perforated galvanized inner liner where indicated

C. Duct liner shall be additionally secured with mechanical fasteners, either weld-secured or impact-driven, which shall compress the duct liner sufficiently to hold it firmly in place. Adhesive bonded pins are not permitted due to long term adhesive aging characteristics. Spacing of mechanical fasteners with respect to duct liner interior width shall be in accordance with SMACNA HVAC DGS. Maximum spacing for mechanical fasteners shall be as follows:

Velocity = 0 to 2,500 feet per minute (0 to 12.8m/s):	
From transverse end of liner	3: (75mm)
Across width of duct	12 inches (300 mm) O.C.
From corners of duct	4 inches (100mm)
Along length of duct	18 inches (450mm) O.C.

Velocity = 2,501 to 5,000 feet per minute (12.8 to 25.4 m/s):	
From transverse end of liner	3 inches (75m)
Across width of duct	6 inches (150mm) O.C.
From corners of duct	4 inches (100mm)
Along length of duct	16 inches (400mm) O.C.

D. When air velocities exceed 4,000 fpm (20.3m/s), galvanized sheet metal nosing shall be applied to all leading edges of duct liner.

E. Acoustical Duct Liner shall be cut to assure overlapping and compressed longitudinal corner joints.

F. Upon completion of installation of duct liner and before operation is to commence, visually inspect the system and verify that the duct liner insulation has been correctly installed.

G. Open all system dampers and turn on fans to blow all scraps and other loose pieces of material out of the duct system. Allow for a means of removal of such material.

H. Check the duct system to ensure that there are no air leaks through joints.

3.4. WATER HEATER INTAKE AND WATER HEATER EXHAUST DUCT INSTALLATION REQUIREMENTS

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NFPA 54 (ANSI Z223.1).

C. Install flue pipes with minimum of joints. Align accurately at connections, with internal surfaces smooth.

D. Support flue pipes from building structure, rigidly with suitable ties, braces, hangers, and anchors to hold to shape and prevent buckling. Support vertical flue pipes, and stacks at 6 foot spacing, to adjacent structural surfaces, or at floor penetrations. Refer to SMACNA HVAC Duct Construction Standards - Metal and Flexible for equivalent duct support configuration and size.

E. Install concrete inserts for support of flue pipes and stacks in coordination with formwork.

F. Pitch flue pipes with positive slope up from fuel-fired equipment to stack.

G. Install vent dampers, locating close to draft hood collar, and secure to flue pipes.

H. Assemble and install stack sections in accordance with NFPA 82, Industry practices, and in compliance with UL listing. Join sections with acid-resistant joint cement to ASTM C105. Connect base section to foundation using anchor lugs.

I. Level and plumb flue pipes and stacks

J. Clean flue pipes and stacks during installation, removing dust and debris.

K. At appliances, provide slip joints permitting removal of appliances without removal or dismantling of flue pipes or stacks.

L. Do not install bull head tee at connections to equipment.

M. Provide and install condensate removal pipes and neutralizers per manufacturer's requirements.

3.5. CLEANING

A. Clean duct system and force air at high velocity through ducts to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning.

B. Clean duct systems with high power vacuum machines. Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes.

C. Ductwork shall be cleaned in accordance with "Duct Cleanliness for New Construction (SMACNA 2000)", and shall achieve a "Basic" cleanliness level.

3.6. LEAKAGE TESTS

A. All low pressure sheet metal ductwork shall undergo leakage tests at 2 inch W.G. Tests shall be accomplished under this section and witnessed as specified under Division 23 Section, "Testing, Adjusting, and Balancing for HVAC and Plumbing".

B. All medium pressure sheet metal ductwork shall undergo leakage tests at 5 inch W.G. Tests shall be accomplished under this section and witnessed as specified under Division 23 Section, "Testing, Adjusting, and Balancing for HVAC and Plumbing".

C. Leakage from each duct system shall not exceed 5 percent for low pressure systems and 1 percent for medium pressure systems of the normal air handling capacity of the system. If the system ductwork is tested in sections, the leakage shall not exceed ½ of 1 percent of the CFM to be handled by that section, and the total leakage of the system shall not exceed 1 percent of the total system CFM. Test pressure shall not exceed the pressure limits of the duct construction as defined in SMACNA High Pressure Duct Construction Standards. Repair all leaks which are audible, regardless of the leakage rate of the duct system as a whole, by remaking the entire defective joint or seam. Spot sealing of ducts in place will not be acceptable.

D. All duct accessories, including but not limited to volume dampers, ATC sensors, motor operated dampers, duct access doors, duct detectors, and duct coils shall be installed prior to duct leakage testing.

E. Submit a complete report of the ductwork leakage tests to the Architect and include final approved copies in test and balance reports.

3.7. DUCTWORK IDENTIFICATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

B. All ductwork shall be identified with painted background marked with the name of the service with arrows to indicate flow direction. Color Code and System Identification shall comply with ANSI Standards.

C. Marking shall be plain block letters, stenciled on ductwork (above and below ceilings) and shall be located near each branch connection and at least every ten feet on straight runs of ductwork. Where ductwork is aligned adjacent to each other, markings shall be neatly lined up. All markings shall be located in such a manner as to be easily legible from the floor.

D. Identify ductwork with plastic nameplates or stenciled painting. Identify with air handling unit/fan identification and area served.

E. Length of fan color field for ductwork shall be 32 inches. Lettering shall be minimum 3-1/2 inches high.

3.8. CLOTHESDRYER DUCTWORK INSTALLATION REQUIREMENTS

A. Install in accordance with manufacturer's instructions.

B. Install clothes dryer ducts with minimum of joints. Align accurately at connections, with internal surfaces smooth.

C. Support clothes dryer ducts from building structure, rigidly with suitable ties, braces, hangers, and anchors to hold to shape and prevent buckling. Support vertical clothes dryer ducts, and stacks at 12 foot (4 m) spacing, to adjacent structural surfaces, or at floor penetrations. Refer to SMACNA HVAC Duct Construction Standards - Metal and Flexible for equivalent duct support configuration and size.

D. Coordinate installation of dryer booster fan.

E. Level and plumb stacks.

F. Clean clothes dryer ductwork during installation, removing dust and debris.

G. At appliances, provide slip joints permitting removal of appliances without removal or dismantling of clothes dryer ductwork, clothes dryer ductwork insulation, or stacks.

H. Do not install bull head tee at connections to equipment.

I. Transition to dryer booster fan

J. Provide and install fitting for installation of dryer booster fan probe as required by dryer booster fan system manufacturer.

K. Install cleanouts at all changes in direction and on both sides of the dryer booster fan.

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PACKAGED KITCHEN HOOD VENTILATION CONTROL SYSTEM
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SECTION 23 82 22 PACKAGED KITCHEN HOOD VENTILATION CONTROL SYSTEMS

PART 1. GENERAL

1.1. RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

A. This Section includes the following:

1. Packaged Kitchen Hood Ventilation Control Systems.

B. Related Sections include the following:

1. Division 11 Section, Food Service Equipment for kitchen hoods.
2. Division 23 Section, Heating, Ventilating, and Air Conditioning for hood make-up units.
3. Division 23 Section, Heating, Ventilating, and Air Conditioning for hood exhaust fans.
4. Division 23 Section, Instrumentation & Controls of HVAC & Plumbing Systems for temperature control and sequences of operation.

C. The kitchen hood demand control ventilation (DCV) control system shall include controls that sense temperature and smoke under the hood and vary the fan speed to maintain safe and effective kitchen exhaust per ASHRAE/ANSI/IES Standard 90.1 2010. Melink Intelli-Hood Demand Control Ventilation (DCV) control system shall monitor cooking activity under the kitchen hood via auto-calibrated infrared Optic Sensors consisting of an Emitter and Receiver mounted on either side of the hood canopy as well as duct or canopy mounted three-wire Temperature Sensor. System shall be capable of operating exhaust fan motors at minimum speeds of 30%-50%. Optic Sensors, with dedicated Air Purge Units, shall immediately increase fan speeds to 100% upon detection of smoke or effluent in the hood canopy with a response time of 0.2 seconds. Upon evacuation of smoke or effluent the fans will modulate according to exhaust temperature for optimal energy savings. System will actively modulate make-up airflow according to exhaust load to maintain correct space airflow balance.

D. Demand Control Ventilation (DCV) system that only includes a temperature sensor to detecting cooking activity shall not be permitted. Additionally a DCV system that includes infrared heat sensors without a dedicated air purge unit and auto-recalibration of sensors shall not be permitted. Modulating dampers or other devices that may impede exhaust airflow and grease extraction shall not be permitted.

E. Modulating dampers or other devices that may impede exhaust airflow and grease extraction shall not be permitted.

1.3. SUBMITTALS

A. Comply with the requirements of Division 01 Section Submittal Procedures.

B. For Approval:

1. Product Data: Include rated capacities, furnished specialties, and accessories.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Prepare the following:

   a. Mounting Details: For securing variable speed drives, temperature sensors, optical sensors, and key pads to kitchen hoods. Indicate coordinating requirements with kitchen hood.
   b. Wiring Diagrams: Power, signal, and control wiring.

3. Coordination Drawings: Equipment mounting details drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

   a. Size and location of variable speed drives, temperature sensors, optical sensors and key pads and methods for anchoring units to kitchen hoods.

C. For Information:

1. Startup service reports.
2. Operation and Maintenance Data: For packaged kitchen hood ventilation control systems to include in emergency, operation, and maintenance manuals.

1.4. QUALITY ASSURANCE

A. Product Options: Drawings performance requirements of packaged kitchen hood ventilation systems are based on the specific system indicated. Refer to Division 01 Section Product Requirements.

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. Control System shall be tested and certified to conform to the following standards.

1. UL 2017 – Standard for General-Purpose Signaling Devices and Systems.
2. UL 710 – Standard for Exhaust Hoods for Commercial Cooking Equipment.
3. FCC Class B Standard CFR47 Part 15.109 on Radiated Emissions.
4. FCC Class B Standard CFR47 Park 15.109 on Conducted Emissions.
5. CSA C22.2 No. 205-M1983 – Signal Equipment.
6. CE Class B Directive 98/34/EEC: Technical Standards & Regulations Directive.
7. CE Class B Directive 2004/108/EC: Electromagnetic Compatibility with Amending Directives 92/31/EEC, 93/68/EEC and 91/263/EEC
8. CE Standard EN 61000-6-3: 2007 Emissions
9. CE Standard EN 61000-3-2: 2006 Harmonic Current Emissions
10. CE Standard EN 61000-3-3: 1995 +A1:2001, +A2:2005 – Voltage Fluctuations and Flicker
11. CE Standard EN 61000-6-1: 2007 Electrostatic Discharge
12. CE Standard EN 61000-6-1: 2007 Radiated Immunity

13. CE Standard EN 61000-6-1: 2007 Electrical Fast Transients
14. CE Standard EN 61000-6-1: 2007 Surge
15. CE Standard EN 61000-6-1: 2007 Conducted Immunity
16. CE Standard EN 61000-6-1: 2007 Voltage Dips and Short Interruptions.

1.5. COORDINATION

A. Coordinate supply fan speed control of make-up air units are specified in Division 23.

B. Coordinate installation of equipment and devices with kitchen hoods. Kitchen hoods are specified in Division 11 Section Food Service Equipment. Coordinate exhaust fan and make-up air unit speed control of hood exhaust fans and make-up air units. Hood exhaust fans are specified in Division 23. Hood exhaust fans and make-up air units are specified in Division 23 Section, "Heating, Ventilating, and Air Conditioning Equipment".

C. Coordinate with Division 23 "Common Work Results for HVAC". Furnish and install motor bearing protective rings at all variable frequency drive motors.

D. Coordinate installation of hood sensors in kitchen hoods listed in Division 11 Food Service Equipment.

E. Coordinate installation of the System Controller(s), Touchpad(s), and Aux Touchpad(s).

F. Coordinate installation of Variable Frequency Drives.

G. Coordinate installation of hood sensor wiring.

H. Coordinate power wiring of System Controller, Auxiliary Power Supplies, and Auxiliary Light Controllers.

I. Coordinate VFD and motor power wiring.

J. Coordinate installation of VFD control wiring and auxiliary contacts on equipment disconnects.

K. Coordinate installation and connections of control wiring for make-up air unit(s), air handling unit(s), pollution control exhaust fan, and any other HVAC equipment related to the kitchen ventilation system.

L. Coordinate supply fan speed and/or damper control of make-up air units or other air handlers to maintain building balance as exhaust fans modulate in speed.

M. Coordinate installation and control wiring of special hood systems.

N. Coordinate fire mode interlock and Sequence of Operation.

O. Coordinate interface of IntelliHood Control system to building automation network via BACnet protocol over TCP/IP.

P. Coordinate connection of IntelliHood Control System to an internet gateway such that IntelliHood System Controller can connect to the Melink IntelliHood Server.

1.6. EXTRA MATERIALS

A. If manufacturer is not capable of providing VFD's with bypasses, then spare kitchen makeup air unit and exhaust fan VFD's shall be provided to Owner.

PART 2. PRODUCTS

2.1. MANUFACTURERS

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

1. Melink Corporation.
2. Greenheck
3. CaptiveAire
4. Or approved Equal

2.2. PACKAGED UNITS

A. Factory assembled, pre-wired, self-contained units consist of processors key pads, temperature sensors, optic sensors, air purge units, and variable frequency drives.

B. The kitchen ventilation control system shall automatically control the speed of the exhaust and make-up air fan(s) to ensure optimal hood performance. The system includes the following: I/O Processor, Keypad, Temperature Sensors, Optic Sensors, Electronic Motor Starters (VFD's which replace magnetic starters for 3-phase motors), and cables.

C. Factory assembled, modular, control system, consisting of the following components:

D. System Controller

1. Communicates to Hood Controller, Touchpad(s), Temperature and Optic Sensors via proprietary RS-485 Protocol.
2. Controller capable of communicating with up to (39) Hood Controllers, (10) Touchpads, (10) Auxiliary Touchpads, (10) Auxiliary Power Supplies, and (10) Auxiliary Light Controllers.
3. Communicates with up to (64) Variable Frequency Drives via Modbus Protocol.
4. Programmable I/O containing (3) Digital Inputs, (4) Digital Outputs, (1) Analog Input and (1) Ana-log Output.
5. Adjustable Temperature range vs. Fan Speed Curve.
6. Automatic On/Off based on hood temperature or programmable clock for individual fan schedules.
7. Removable USB memory storage for setup files and operational performance history data.
8. Calculates appropriate speeds for exhaust and supply fans based on cooking temperature demand and optical infrared monitoring.
9. Internet-based Service Application for monitoring, programming and troubleshooting.
10. BACnet over TCP/IP Interface for communication to Building Automation System.

11. Internet-based Service Application for programming and monitoring

    a. Monitoring can be done using hard-wired Ethernet plug-in or 4G wireless modem.

2.3. I/O PROCESSOR

A. Processor shall be housed in painted enclosure for durable construction and a smooth finish. The processor shall have the capability of interfacing with up to four (4) pairs of optic sensors, four (4) temperature sensors, four (4) electronic motor starter interfaces plus supply fan command and eight (8) Air purge units. When required provide multiple processors should the quantity of hoods/fans exceed four (4) per processor. The processor shall include the following:

1. Auto Start/Stop Command and Timer function.
2. Winter Setback Mode.
3. Comfort Mode: Utilizes cool outside air to keep kitchen comfortable.
4. Smoke Detection Relay.
5. Two (2) alarm relays for controlling external devices based on exhaust temperature.
6. Plug-n-play cables provided for quick and easy installation.
7. 4-20 milliamp signal output.

B. Hood Controller

1. Monitors Temperature and Optic Sensors on each kitchen hood and sends the sensor data to the System Controller via RS-485 Protocol communications.
2. Steel beam clamps for installation on hoods or other mechanical structures above kitchen hood.
3. Hood Controller Temperature Rating: 0° to 50°C, 32° to 120°F

2.4. KEYPAD

A. Touchpad

1. Full color screen, 2.8” diagonal, QVGA resolution screen to display operating status and programmable menus.
2. Integrated membrane FANS switch for turning fans from Active Mode (On) and Standby Mode (off).
3. Integrated membrane LIGHTS switch for turning hood lights On / Off via line voltage relays to change state of line voltage.
4. Soft keys and Directional integrated membrane switches for user to boost fans to full speed, access programming menus, access diagnostic and help screens.
5. Fully programmable graphical interface to conform to operators’ hood and fan nomenclature.
6. Provide keypad for each hood.

B. Aux Touchpad

1. Aux Touchpad shall be used as an additional user interface, if applicable, for the control of the FANS, LIGHTS and 100% switches.

2. Integrated membrane FANS switch shall change associated hoods between Active Mode (fans running) to Standby Mode (fans off).
3. Integrated membrane LIGHTS switch shall change the state of associated line voltage relays which may be used to control Hood Lights circuits.
4. Integrated membrane 100% Switch shall allow users to temporarily boost fan speeds to full speed on associated hoods.
5. Stainless steel cover plate (304L) for durable construction and smooth finish.
6. Synthetic overlay for water protection.

C. Aux Power Supply

1. Aux Power Supply shall be used for large installations when additional power is needed to power Hood Controllers, Optic Sensors and Touchpads.
2. Aux Power Supply Temperature Rating: 5° to 40°C, 41° to 104°F

D. Aux Lighting Controller

1. Aux Lighting Controller shall be used for large installations where there is a need to control multiple hood light circuits.
2. Aux Lighting Controller Temperature Rating: 5° to 40°C, 41° to 104°F

2.5. TEMPERATURE SENSOR(S)

A. Platinum three-wire resistive temperature device (RTD) encased in stainless steel tube.

B. Threaded housing shall be assembled in UL-Listed grease-tight fittings for installation in exhaust duct or kitchen hood canopy.

C. Temperature sensors shall be wired to Hood Controller via 8-pin, RJ-45 connectors to the RS-485 Protocol Hood Network Cables.

D. Temperature Rating: 0° to 535°C, 32° to 1000°F

2.6. OPTIC SENSOR(S)

A. Optic Sensors shall consist of conformal coated Emitter and Receiver boards housed in stainless steel enclosures on opposite ends of the kitchen hood interior.

B. Infrared sensors capable of detecting effluent in the air at any point along the length of the beam with a response time of 0.2 seconds.

C. Sensors shall be capable of spanning 3 to 40 feet of kitchen hood interior with automatic gain adjustment.

D. Optic sensors shall auto-calibrate every day at start up and/or every 24 hours.

E. Sensors shall be wired to Hood Controller with liquid-tight connectors at sensor board via the Air Purge Unit.

F. Optic Sensor Temperature Rating: 0° to 85°C, 32° to 185°F

2.7. AIR PURGE UNIT(S)

A. Air Purge Unit (APU) consisting of a 12VDC blower and interface PCB inside an 18 gauge galvanized steel enclosure shall be installed to reduce the accumulation of contamination on the Optic Sensor lenses and reduces heat buildup inside the Optic Sensor enclosure.

B. APU shall physically connect to the Optic Sensor enclosure via stainless steel conduit pipe.

C. Blower fan bearings shall be permanently lubricated.

D. APU Temperature Rating: 0° to 50°C, 0° to 125°F

2.8. ELECTRONIC MOTOR STARTERS

A. Variable frequency drives (VFD) shall be used to control the exhaust and supply fan motors. The VFD modulates the speed of the fan motors by varying the output voltage and frequency based on a signal received from the controller. The VFD will send a feedback signal to the controller in or-der for the keypad to display the actual speed of the motor. The variable frequency drives shall have the following characteristics:

1. NEMA 1 Enclosure.
2. Full across the line bypass/starter or spare supply air/exhaust air fan VFDs.
3. Soft-Start Capability.
4. Digital keypad displays output frequency, current, voltage, and allows programming for field modifications.
5. Protective functions: motor overload, overheating, overcurrent, overvoltage, output shorts, etc.
6. High and low frequency limiters.
7. Adjustable torque boost.
8. Plug-n-play cables provided for quick and easy installation.
9. Single point power connection.
10. Coordinate exact size of VFDs based on approved submittals for make-up air units and exhaust fans.
11. VFDs shall be provided under this Division and shall be remote mounted where shown on the Contract Drawings.
12. Building Automation System shall acquire VFD control data (stop, start, speed, fault status) from IntelliHood System Controller via BACnet Protocol over TCP/IP Communication.
13. Phase loss protection.

2.9. MOTORS

A. General requirements for motors are specified in Division 23 Section "Common Work Results for HVAC".

B. Motors controlled by Variable Frequency Drives should be designed and tested to meet recommendations of NEMA MG1, Part 31.

1. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Di-vision 26 Sections.

C. Furnish and install shaft grounding rings on all motor shafts.

PART 3. EXECUTION

3.1. EXAMINATION

A. Examine substrates areas and conditions with Installer present for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Delete first subparagraph below if not required.

C. Examine roughing-in for hood suppression piping, hood exhaust ductwork systems to verify actual locations of piping connections before equipment installation.

D. Examine kitchen hoods and ceilings for suitable conditions where variable frequency drives will be installed.

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

3.2. INSTALLATION

A. Install packaged kitchen hood ventilation control systems per manufacturer's requirements.

B. Install interlock wiring between motors and variable frequency drives.

C. Install processors and variable frequency drives in the utility cabinet.

D. Install wiring to shunt trip breakers and gas solenoid valves. Interlock with fire alarm system.

E. Install temperature sensors in exhaust duct collars.

F. Install optic sensors in the inside ends of each hood with air purge units mounted on top.

G. Wire system components with plug-in-play cables.

H. Install controls and equipment shipped by manufacturers for field installation with packaged kitchen hood ventilation control system.

I. Mount key pads at all kitchen hoods. Coordinate with Owner to ensure accessibility of location.

J. Install and interlock air flow monitoring station. Interlock with ATC system.

K. Program VFD parameters in the kitchen make-up unit and kitchen hood exhaust fan drives. Parameters shall be determined by Test/Balance Engineer and the same should be noted on the inside door of the make-up air unit and adjacent to the exhaust fans and drives.

L. Assist the Automatic Temperature Control Contractor with mapping over points to the BMS.

3.3. CONNECTIONS

A. Install sensors, cabinet, variable speed drives and key pads adjacent to kitchen hoods to allow service and maintenance.

B. Ground equipment according to Division 26 Section Grounding and Bonding.

C. Connect wiring according to Division 26 Section Conductors and Cables.

D. Interlock packaged kitchen control system with ATC system.

E. Where a local motor disconnect is indicated downstream of the electronic motor starter (VFD), provide interlock wiring from auxiliary contacts on the disconnect to the electronic motor starter to de-energize the VFD when the local disconnect is turned “off”.

3.4. FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

3.5. STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Programming of system parameters for proper detection of cooking conditions.
3. Programming of system parameters for proper operation of control input/output points.
4. Programming of VFD parameters for proper control communication with control system.
5. Programming of VFD motor operational set points (maximum speed and allowable motor current).
6. Verification of IntelliHood system functionality.
7. Results shall be captured in a written report.

3.6. ADJUSTING

A. Adjust initial temperature and optic sensor set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Adjust variable frequency drives and fan speed set points. Coordinate with Test and Balance Engineer.

D. Adjust pre-set minimum supply fan and exhaust fan(s) air flow rates.

3.7. DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain Packaged Kitchen Hood Ventilation Control Systems. Refer to Division 01 Section Closeout Procedures and Demonstration and Training.

END OF SECTION