SECTION 232323 – STEAM CONDENSATE PUMPS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Provide Low Pressure Steam Condensate pumping system as required on this Project and as needed for a complete and proper installation; product specific requirements are contained here; Section 230100, General Provisions for Heating, Ventilating and Air Conditioning Work, shall be referred to for general requirements.

B. All insulation materials shall be free of asbestos.

1.02 RELATED SECTIONS

A Division 23 Sections

B. Division 26 Sections

C. Division 16 Sections

1.1 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 23 22 23, STEAM CONDENSATE PUMPS”, with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

1. Pumps and accessories.
2. Motors and drives.

D. Characteristic Curves: Head-capacity, efficiency-capacity, brake horsepower-capacity, and NPSHR-capacity for each pump //and if specified, for dual parallel pump operation//.

E. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

F. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician, and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

G. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.2 QUALITY ASSURANCE

A. Design Criteria:

1. Pumps design and manufacturer shall conform to Hydraulic Institute Standards.
2. Pump sizes, capacities, pressures, operating characteristics, and efficiency shall be as scheduled.
3. Select pumps so that required net positive suction head (NPSHR) does not exceed the net positive head available (NPSHA).
4. Pump Driver: Furnish with pump. Size shall be non-overloading at any point on the head-capacity curve including one pump operation in a parallel or series pumping installation.
5. Provide all electric-powered pumps with motors, impellers, drive assemblies, bearings, coupling guard and other accessories specified. Statically and dynamically balance all rotating parts.
6. Furnish each pump and motor with a nameplate giving the manufacturers name, serial number of pump, capacity in gpm and head in feet at design condition, horsepower, voltage, frequency, speed and full load current and motor efficiency.
7. Test all pumps before shipment. The manufacturer shall certify all pump ratings.
8. After completion of balancing, provide replacement of impellers or trim impellers to provide specified flow at actual pumping head, as installed.
9. Furnish one spare seal and casing gasket for each pump to the COR.

1.3 AS-BUILT DOCUMENTATION

A. Submit manufacturer’s literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations

and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:
   1. Red-lined, hand-marked drawings are to be provided, with one paper copy and a scanned PDF version of the hand-marked drawings provided on CD or DVD.
   2. As-built drawings are to be provided, with a copy of them on AutoCAD version provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.
   3. As-built drawings are to be provided, with a copy of them in three-dimensional Building Information Modeling (BIM) software version provided on CD or DVD.
D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.
E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

PART 2 - PRODUCTS

2.1 CONDENSATE PUMP, PAD-MOUNTED

A. General: Factory assembled unit consisting of vented receiver tank, motor-driven pumps, interconnecting piping and wiring, motor controls (including starters, if necessary) and accessories, designed to receive, store, and pump steam condensate.

B. Receiver Tank: Cast iron with threaded openings for connection of piping and accessories and facilities for mounting float switches. Receivers for simplex pumps shall include all facilities for future mounting of additional pump and controls.

C. Furnish seals for condensate pump with a minimum temperature rating of 121 degrees C (250 degrees F).

D. Centrifugal Pumps: Bronze fitted with mechanical shaft seals.

1. Designed to allow removal of rotating elements without disturbing connecting piping or pump casing mounting.
2. Shafts: Stainless steel, Type 416 or alloy steel with bronze shaft sleeves.
3. Bearings: Regreaseable ball or roller type.
4. Casing wearing rings: Bronze.

E. Motors: Refer to Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.

F. Pump Operation:

1. Float Switches: NEMA 4, mounted on receiver tank, to start and stop pumps in response to changes in the water level in the receiver and adjustable to permit the controlled water levels to be changed. Floats and connecting rods shall be copper, bronze or stainless steel.
2. Alternator: Provide for duplex units to automatically start the second pump when the first pump fails in keeping the receiver water level from rising and to alternate the order of starting the pumps to equalize wear. For units 0.25 kW (1/3 hp) and smaller, the alternator may be the mechanical type for use in lieu of float switches.

G. Control Cabinet for 3 Phase (0.37 kW (1/2 hp) and larger) Units: NEMA 4, UL approved, factory wired, enclosing all controls, with indicating lights, manual switches and resets mounted on the outside of the panel. Attach cabinet to the pump set with rigid steel framework, unless remote mounting is noted on the pump schedule.

1. Motor starters: Magnetic contact types with circuit breakers or combination fusible disconnect switches. Provide low voltage control circuits (120-volt maximum) and HOA switches for each pump.

2. Indicating lights for each pump: Green to show that power is on, red to show that the pump is running.

H. Electric Wiring: Suitable for 94 degrees C (200 degrees F) service; enclosed in liquid-tight flexible metal conduit where located outside of control cabinet.

I. Receiver Accessories:

1. Thermometer: 38 to 216 degrees C (100 to 420 degrees F), mounted below minimum water level.
2. Water level gauge glass: Brass with gauge cocks which automatically stop the flow of water when the glass is broken. Provide drain on the lower gauge cock and protection rods for the glass.

2.2 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

D. Verify that the piping system has been flushed, cleaned and filled.

E. Lubricate pumps before startup.

F. Prime the pump, vent all air from the casing and verify that the rotation is correct. To avoid damage to mechanical seals, never start or run the pump in dry condition.

G. Verify that correct size heaters-motor over-load devices are installed for each pump controller unit.

H. Field modifications to the bearings and or impeller (including trimming) are prohibited. If the pump does not meet the specified vibration tolerance send the pump back to the manufacturer for a replacement pump. All modifications to the pump shall be performed at the factory.

2.3 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

2.4 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer's technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

END OF SECTION 23 23 23

DIVISION 23 HEATING, VENTILATING AND AIR CONDITIONING (HVAC) SECTION 232513 – CHEMICAL WATER TREATMENT, CLOSED LOOP WATER SYSTEMS SPEC EDITOR: THE CHILLED WATER SYSTEM AT UNIVERSITY HOSPITAL IS A HYBRID CLOSED/OPEN LOOP SYSTEM; THIS SPECIFICATION MUST BE SPECIALLY MODIFIED WHEN USED FOR WORK ON THAT SYSTEM. CONTACT THE U-M DESIGN MANAGER FOR DIRECTION. JAN. 2017: ADDED U.S. WATER AS APPROVED CSP PER STM/HYDRONICS MTT. D. KARLE SEPT. 2017: REMOVED GE WATER AS APPROVED CSP PER HYDRONICS AND STEAM MTT DUE TO POOR SERVICE. D. KARLE JUNE 2018: ADDED NOVATECH AND ADVANTAGE CONTROLS AS APPROVED MFR.S FOR COUPON RACKS, DELETED VECTOR INDUSTRIES (DOES NOT MAKE RACKS), PER REQUEST OF FACILITIES MAINTENANCE/N. VANDERKOLK. D. KARLE. FEB. 2019: REVISED CROWN SOLUTIONS TO VEOLIA WATER, NEW CORPORATE NAME. D. KARLE PART 1 - GENERAL 1.1 RELATED DOCUMENTS INCLUDE PARAGRAPH 1.1.A AND B IN EVERY SPECIFICATION SECTION. EDIT RELATED SECTIONS 1.1.B TO MAKE IT PROJECT SPECIFIC. A. Drawings and general provisions of the Contract, Standard General and Supplementary General Conditions, Division 1 Specification Sections, and other applicable Specification Sections including the Related Sections listed below, apply to this Section. SPEC EDITOR: IN 1 AND 2 BELOW, SELECT PROPER SPEC SECTION NUMBER BY PROJECT. DELETE SUSTAINABLE DESIGN / LEED IF NOT APPLICABLE TO THE PROJECT. B. Related Sections: 1. Section 018113 - Sustainable Design Requirements 2. Section 019110/019100 - Facilities Commissioning 3. Section 220500 - Common Work Results for Mechanical 4. Section 221113 - Piping Materials and Methods 5. Section 220523 - Valves 6. Section 220519 – Thermometers, Pressure Gauges, and Accessories 7. Section 220553 - Mechanical Identification 8. Section 220719 - Mechanical Systems Insulation 1.2 SUMMARY A. Products specified in this section include the following: 1. Chemical Inhibitors for Water 2. Chemicals for Inhibitors and cleaning 3. Shot Feeder BuildingName The Description of the Project P00000000 0000 Issued for:BID 232513 – - 2 4. Corrosion Coupon Rack 5. Glycol Feed System 6. Ethylene Glycol B. Provide a Chemical Services Provider (CSP) to perform the services described below. C. Provide water treatment products and services including: 1. Chemicals for cleaning, passivation, and treatment of each system. 2. On-going treatment, chemicals, testing, certification, and reports to demonstrate effective water treatment is maintained at all times. 3. Start-up and operation of chemical treatment equipment. D. Provide a complete chemical water treatment program during construction for all new and reused piping networks. This program shall begin from the point each system is filled during construction and extend until Substantial Completion or final Owner acceptance of each system, whichever occurs later. The program shall include water analysis, chemicals, testing, equipment, consulting and service for the following systems: 1. Heating Hot Water System 2. Chilled Water System 3. Dual Temperature Water System 4. Process Cooling System 5. Glycol System 6. All other closed loop systems E. Attend project meetings as required to plan, schedule and coordinate above activities with other project contractors and the Owner. F. Provide recommended testing procedures and chemical treatment schedule for Owner's personnel. This information shall be submitted to the owner in a Program Administration Manual. 1.3 SUBMITTALS A. Product Data: Include rated capacities; water-pressure drops; shipping, installed, and operating weights; and complete data on furnished products listed below: 1. Shot Feeders 2. Coupon Racks 3. Glycol Feed System 4. Flow Indicators 5. Valves 6. Product specifications and MSDS's for each chemical used

7. Cleaning Procedures 8. Passivation Procedures 9. Chemical Treatment Procedures 10. Shop Drawings B. Shop Drawings to include detailed equipment assemblies indicating dimensions, weights, loads, required clearances, method of field assembly, components, and the location and size of each field connection as necessary to assist the mechanical contractor with proper system installations BuildingName The Description of the Project P00000000 0000 Issued for:BID 232513 – - 3 C. Submit resume of water treatment personnel and name of Chemical Services Provider. D. Service Reports as indicated under Part 2 below. 1.4 QUALITY ASSURANCE A. Manufacturers and Products: The products and manufacturers specified in this Section establish the standard of quality for the Work. Subject to compliance with all requirements, provide specified products from the manufacturers named in Part 2. B. Products in this section shall be built, tested, and installed in compliance with the specified quality assurance standards; latest editions, unless noted otherwise. 1. American Society for Testing and Materials (ASTM) a. D859 – Test Method for Silica in Water b. D1067 – Test Methods for Acidity/Alkalinity in Water c. D1068 – Test Methods for Iron in Water d. D1126 – Test Method for Hardness in Water e. D3370 – Practices for Sampling Water from Closed Conduits f. D4012 - Test Method for Adenosine Triphosphate (ATP) Content of Microorganisms in Water g. D5465 - Practice for Determining Microbial Colony Counts from Waters Analyzed by Plating Methods C. Conform to all applicable Codes, Regulations, and Municipal requirements for the use and disposal of chemicals (including cleaning compounds) and waste to public sewer systems. 1. Wastewater shall be discharged to the sanitary sewer only if it has a pH between 5.0 and 10.0 and meets the requirements of the City of Ann Arbor Sewer Use Ordinance. For wastewater not meeting such criteria, contact U-M Occupational Safety and Environmental Health (OSEH) Hazmat at 734-763-4568 for proper disposal instructions. City of Ann Arbor Sewer Use Limitations can be found at the following website: http://www.municode.com/resources/gateway.asp?pid=11782&sid=2 2 or by contacting U-M OSEH Environmental Protection & Permitting Program (EP3) at 734-936-1920 2. Glycols (of any type) shall not be discharged to the sanitary sewer. Contact U-M OSEH HazMat at 734-763-4568 for proper disposal instructions. D. Wastewater containing any chemical or sediment is prohibited from discharge to the storm water system. No chemical shall contain Chromates or Inorganic Phosphates. 1.5 DELIVERY, STORAGE, AND HANDLING A. Package for delivery to best protect finished surfaces while using the least amount of single-use packaging as possible. Deliver equipment and components adequately packaged for lifting, skidding, or rolling into final position, according to manufacturer's instructions. If possible, package and ship products using reusable blankets and fabrics, or reusable cardboard and crate systems. BuildingName The Description of the Project P00000000 0000 Issued for:BID 232513 – - 4 B. Store materials and equipment raised off the floor on pallets and protected with coverings to prevent damage due to weather and construction activities. Store in areas that prevent damage due to freezing and extreme temperatures or sunlight. Arrange coverings to provide air circulation to avoid damage from condensation or chemical build-up. Protect from damage, dirt and debris at all times. C. Store chemicals in curb protected area. Such secondary containment areas must have the capacity to hold the volume of the largest container or 10% of the combined containers, whichever larger. If room has no floor drains, then the room itself may be considered sufficient secondary containment. If the room is considered the secondary containment ensure there is a lip at the door so no liquids can exit the room in the event of a leak. Verify field conditions before storing any chemicals 1. Provide temporary containment areas when permanent containment areas do not exist. Remove temporary containment at the end of construction. 1.6 WARRANTY A. Provide a complete warranty for parts and labor for a minimum of one year from the date of Substantial Completion. This warranty does not include ongoing chemical treatment or monitoring. 1.7 ACCEPTABLE CHEMICAL SERVICE PROVIDERS (CSPS) A. Approved CSPs 1. Chemtreat 2. Veolia Water 3. Kroff 4. Mitco 5. Nalco 6. Rochester Midland 7. U.S. Water Services PART 2 - PRODUCTS 2.1 GENERAL A. CSP Services: 1. The CSP shall provide all cleaning and treatment chemicals, basic services, testing, equipment and materials necessary for a complete water treatment program. BuildingName The Description of the Project P00000000 0000 Issued for:BID 232513 – - 5 2. The CSP shall perform an analysis of the supply water to determine the type and quantities of chemical treatment needed to maintain the required water quality to prevent corrosion, scaling, and biological growth. The CSP will at minimum provide weekly site visits to verify proper water treatment for the first month after any system or part

of a system is treated. Provide monthly visits thereafter, or more often if required to assure performance requirements are being met, to analyze water samples, inspect equipment, and add additional chemicals as required to maintain proper water treatment, until final written Owner acceptance of the respective system. 3. At each site visit CSP shall analyze each system for corrosion inhibitors, pH, total iron, total copper, bacteria levels (provide monthly analytical laboratory analysis), and conductivity; inspect loss from corrosion coupons (provide analytical laboratory analysis every three months), record make-up meter readings, and perform any other tests necessary to validate that corrosion, scale, and organic growth is being prevented. 4. Reports: a. Submit a written startup test report for each system placed into service. b. A service report shall be prepared on site by the CSP, submitted at the time of each service visit (with copies immediately provided to the Owner and Commissioner), which shall include all required test results and recommendations. c. Additionally, provide final reports for approval to the Owner and Commissioner regarding each site service visit, certified by an Officer of the CSP, within one week of any water treatment activity. Such reports shall include the results of any field or lab tests. Reports shall clearly state if the required water quality and maximum corrosion rates are being achieved. d. At a minimum, each report shall include the following information: 1) System Treated: 2) Date 3) Conductivity 4) pH 5) Total Iron 6) Total Copper 7) Bacteria(cfu) (monthly analytical laboratory analysis) 8) Coupon Corrosion Rates (three month analytical laboratory analysis) 9) Make-up Water Quantity since Last Visit 10) Corrosion Inhibitor level (ppm) 11) Silica level (ppm) 5. Conduct final on-site system turn over meeting with Owner and Commissioner. Present final validation report demonstrating that performance requirements have been achieved and that each system is currently properly treated. 6. When required by Part 3, train Owner's maintenance personnel in water treatment procedures. 7. Program Administration Manual: BuildingName The Description of the Project P00000000 0000 Issued for:BID 232513 – - 6 a. The CSP shall provide the Owner with two (2) Program Administration Manuals including sections covering program control, testing requirements, in plant logs, safety data and system information. Each section shall include the following: 1) Program Control: Include a complete program outline with chemical descriptions, control ranges, and required action for “out of range” situations. Also include complete ordering instructions with applicable account numbers and phone numbers. 2) Testing Requirements: This section will include basic testing practices as well as detailed test instructions for each test to be performed. 3) In-Plant Logs: Include detailed testing log sheets for each system to be tested including room to record one (1) month’s data on one (1) sheet and a section to log chemical inventory. 4) Safety Data: Include the CSP’s 24-hour toll free safety hotline number as well as MSDS sheets for each chemical used. 5) System Information: Include any equipment manuals and related information. 2.2 TREATMENT PROGRAM – FLUSHING AND CLEANING A. Cleaning chemicals shall be non-phosphate and non-acidic. B. Flush and clean all new and reused piping. C. Provide a flush/clean plan for approval. Provide and later remove all temporary bypasses, drains, vents, etc. required to flush and clean the system. Temporary components for flushing and cleaning are not indicated on the drawings. D. Flush and clean systems per the general procedures specified in Related Sections; clean systems per the approved cleaning procedures submitted under this specification section. Provide and install all required cleaning chemicals. E. Verify that adequate cleaning chemical was added, that cleaning was effective, and test that cleaning chemicals were properly rinsed from the system. Provide a report certifying that cleaning and rinsing, was properly executed. F. Provide passivation and chemical treatment immediately after each system has been cleaned and flushed. Systems shall not stand filled with fluids for periods longer than 48 hours without beginning flushing and cleaning which shall immediately be followed by the passivation and chemical treatment procedures. BuildingName The Description of the Project P00000000 0000 Issued for:BID 232513 – - 7 2.3 TREATMENT PROGRAM – CHEMICAL TREATMENT AND PASSIVATION A. Provide passivation and chemical treatment per the approved chemical treatment procedures. Chemically treat new and reused piping networks using chemicals and treatment procedures compatible with the system being cleaned and the chemical treatment chemicals in existing piping systems being connected to. Test existing piping systems or otherwise determine chemical treatment in existing piping and validate compatibility. Note that existing systems may be silica based, adjust water treatment program accordingly. SPEC EDITOR: WHEN CONNECTING INTO EXISTING ACTIVE SYSTEMS, DEVELOP A COORDINATION PLAN IN CONSULTATION WITH U-M PLANT

AND REVISE THE BELOW SAMPLE PARAGRAPH ACCORDINGLY. THIS SPECIFICATION REQUIRES POLYMER BASED INHIBITORS, EXISTING SYSTEMS MAY BE SILICA BASED. IT MAY BE DESIRABLE TO CONVERT THE EXISTING PIPING NETWORK TO POLYMER BASED AS A PART OF YOUR PROJECT. B. When connecting into active existing systems, treat piping networks installed or reused by the project and verify by lab analysis that the treatment levels per the treatment plan have been attained prior to connecting into the existing active system. Submit validating report for approval. 1. Do not connect into existing active system until report is approved by Owner. 2. Provide temporary valves, piping, and accessories as required to treat the project's piping prior to connection to the active system. C. Provide passivation/chemical treatment at system startup or immediately upon operation of a system for temporary cooling and heating, whichever comes first. D. Provide chemical treatment immediately after each system has been cleaned and flushed. Thereafter immediately begin the approved water treatment maintenance program to passivate and prevent corrosion, scale, and organic growth and to maintain treatment chemical levels. Note that systems or parts of systems will not typically be started at the same time; adjust treatment strategy accordingly. E. Provide chemicals that comply with State and Federal regulations. F. Chemical inhibitor shall be polymer based and contain azole in an amount appropriate for the percentage of internal copper surface area of the system piping. Provide products with PTSA (pToluenesulfonic acid) florescent tracer dyes. Molybdenum shall not be used as a tracer. Optionally, for hot water heating systems only, nitrite/azole based inhibitors may be used. G. No chemicals shall contain chromates or inorganic phosphates. H. Utilize non-oxidizing biocides in the event sterilization is required. I. Adjust chemical concentrations as required to achieve the required performance BuildingName The Description of the Project P00000000 0000 Issued for:BID 232513 – - 8 2.4 PERFORMANCE REQUIREMENTS A. The water treatment programs proposed by the CSP shall maintain corrosion rates below 0.5 mils per year for mild steel and 0.1 mils per year for copper. These rates shall be verified with corrosion coupons provided by the CSP Coupons shall be analyzed in the CSP's analytical laboratory every three months, more often if required, to assure these levels are not exceeded. B. Microbiological growth levels shall be maintained below 10,000 cfu's aerobic bacteria and 10 cfu's anaerobic bacteria. The CSP shall perform detailed microbiological culturing at the CSP's company's analytical laboratory monthly, more often if required, to assure these levels are not exceeded 2.5 EQUIPMENT A. Provide all components required for a fully operational water treatment system. Provide components that are not adversely affected by the treatment chemicals employed. CHEMICAL SHOT FEEDERS: OTHER MFR.S OF SHOT FEEDERS SUCH AS WINGERT AND VECTOR OFFER ONLY QUARTER-TURN STYLE TOPS WHICH U-M PLANT HAS DETERMINED TO BE UNSAFE. IF OTHER MFR.S CAN BE FOUND THAT INCLUDE ALL THE FEATURES LISTED BELOW, THEY MAY BE ADDED AS ACCEPTABLE MFR.S. B. Chemical Shot Feeders: 1. Acceptable Manufacturers: a. Neptune 2. Provide shot feeders for each system. Provide steel 5-gallon minimum tank with interior and exterior epoxy coating, removable screwed and gasketed top (4" diam. minimum), pipe threaded inlet and outlet, dish bottom style with floor skirt, rated at 200 psi, 200°F. C. Corrosion Coupon Rack: 1. Acceptable Manufacturers: a. Cannon Water Technology b. J.L. Wingert c. Advantage Controls d. Novatech 2. Supply for each corresponding shot feeder: a. Chilled water: ¾" stainless steel coupon rack, with two coupon holders, inlet/outlet 316 stainless steel full port ball valves, and a ¼" sample valve. Include a 0-5 gpm nominal range variable area flow meter ("rotameter"), rated 150 psig at 70°F, with graduated polysulfone or acrylic cylinder, with an accuracy of +/-5%. Provide mild steel and copper coupons. BuildingName The Description of the Project P00000000 0000 Issued for:BID 232513 – - 9 b. Heating hot water and dual temperature systems: ¾" stainless steel coupon rack, with two coupon holders, inlet/outlet 316 stainless steel full port ball valves, and a ¼" sample valve. Include a 0-5 gpm nominal range variable area flow meter("rotameter"), rated 100 psig at 250°F, graduated glass cylinder with stainless steel or brass connections, with an accuracy of +/-2%. Provide mild steel and copper coupons. SPEC EDITOR: GLYCOL FEED SYSTEMS MUST BE INSTALLED WITHIN A CONTAINMENT AREA, CONTACT U-M DESIGN MANAGER FOR SPECIFIC REQUIREMENTS. D. Glycol Feed System: 1. Acceptable Manufacturers: a. J.L. Wingert Co. b. Neptune Chemical Pump Co. c. Advantage Controls Inc. d. Wessels Co. 2. Provide a floor mounted packaged glycol feed system that is pre-wired and pre-plumbed, and includes a storage tank, control

panel, controls, pump, piping, and valves, all supported on a steel frame. 3. Provide a 50-gallon minimum translucent polyethylene single wall tank with polyethylene cover. Minimum ¼ inch thick walls. 4. Provide a welded steel stand suitable for floor mounting and painted with two coat system consisting of oxide primer and alkyd enamel finish. Provide holes in the base for the installation of anchor bolts and leveling of equipment. 5. Provide a bronze gear pump, 120 V, single phase, and rated for a minimum of 1.5 gpm at 90 psig. 6. Valves and Piping: Pump suction shall include ball valve and Y-strainer. Pump discharge shall include silent check valve, pressure switch, pressure gauge, and 150 psi relief valve piped back to tank. All piping shall be Type L Copper. Connect pump suction and discharge with braided stainless steel or bronze flex connectors. All piping, valves and accessories shall conform to Related Sections. 7. Provide a NEMA 4X control panel with 8 foot, 120 V grounded power cord. Equip the panel with motor starter, 2-position main power switch with light, hand /off/ auto switch with light for gear pump, low level red light, low level audible alarm with push button silence switch, dry contacts for remote monitoring of alarm, and a 15 amp fuse. SPEC EDITOR: PROVIDE THE PRESSURE SWITCH RANGE AND SET POINT EITHER IN THE BELOW PARAGRAPH OR ON THE PROJECT DRAWINGS. 8. Provide an adjustable pressure switch, selected with a range to match system operating pressure. 9. Provide electrical components that conform to Division 26 requirements. Provide all wiring in conduit. Loose, exposed or unprotected wire is not acceptable SPEC EDITOR: REVISE CONCENTRATION IN ARTICLE BELOW AS REQUIRED: AT MINUS 15°F, A CONCENTRATION OF 30% IS RECOMMENDED FOR BURST PROTECTION, 45% FOR FREEZE PROTECTION. FREEZE PROTECTION BuildingName The Description of the Project P00000000 0000 Issued for:BID 232513 – - 10 CONCENTRATIONS ALLOW FLUID TO BE PUMPED. EDITOR SHOULD CAREFULLY DETERMINE IF THE CONCENTRATION IS FOR BURST PROTECTION OR FREEZE PROTECTION. AVOID SPECIFYING EXCESS CONCENTRATIONS SINCE FLUID HEAT TRANSFER RATE DECREASES AS CONCENTRATION INCREASES. DO NOT SPECIFY ETHYLENE GLYCOL FOR SNOW MELTING SYSTEMS; USE PROPYLENE GLYCOL. 2.6 PREMIXED INHIBITED ETHYLENE GLYCOL A. Acceptable Manufacturer and Product: 1. Dow Chemical – Dowtherm SR-1 B. Provide for hydronic systems as indicated on the drawings. C. Provide inhibited ethylene glycol, factory pre-mixed with water at a concentration of 30% by volume Dowtherm SR1. PART 3 - EXECUTION 3.1 EXAMINATION AND PREPARATION A. Pre-Treatment Conference: Prior to treatment activities, meet with the Project Engineer, Commissioner and contractors to verify treatment procedures, discuss coordination with existing piping networks, and to coordinate treatment activities with construction schedule. B. Flush and clean systems per Related Sections and Part 2 above. 3.2 INSTALLATION A. Install all required components, and chemically passivate/treat and maintain the system as described in Part 2. B. Use and dispose of chemicals and wastewater (including from existing piping networks) per the Quality Assurance section of this specification. All costs of disposal shall be borne by the contractor. C. Provide and install all chemicals and all incidental components. Install equipment at locations shown on the Drawings. Follow the manufacturer’s installation and startup instructions. D. Passivate and chemically treat each system immediately after it has been cleaned and flushed. E. Install shot feeders with openings no higher than 4’ above finished floor. Pipe shot feeder drain to nearest floor drain. Install top coupon of corrosion coupon rack no higher than 6’ above finished floor. SPEC EDITOR: SOME PROJECTS, SUCH AS HOSPITAL PROJECTS, MAY DESIRE THAT WATER TREATMENT SERVICES CONTINUE BEYOND SUBSTANTIAL COMPLETION, E.G. A ONE OR MORE YEAR SERVICE CONTRACT. CONTACT THE U-M DESIGN MANAGER FOR DIRECTION, AND IF NEEDED, REVISE THE PARAGRAPH BELOW TO INCLUDE THAT REQUIREMENT. BuildingName The Description of the Project P00000000 0000 Issued for:BID 232513 – - 11 F. The treatment program shall begin at system start-up or immediately upon first operation of the system by the contractor for temporary heating and cooling, whichever comes first. Continue the program until Substantial Completion. 3.3 INSTALLATION OF PREMIXED INHIBITED ETHYLENE GLYCOL SYSTEM A. Following system flushing and cleaning, drain the entire piping system. Add premixed ethylene glycol/inhibitor solution into the system. Circulate system fluid, adding additional pre-mixed glycol/inhibitor as required until all air is purged from the system. B. Sample fluid, measure concentration of glycol and inhibitor. Drain system fluid as required and add additional pre-mixed

solution to achieve the design concentration of glycol and the manufacturer's recommended concentration of inhibitor. Submit report of activities, including volumes of all fluids used. 3.4 INSTALLATION OF GLYCOL FEED SYSTEM A. Level and bolt Glycol Feed System to the floor within the containment area. Support all piping and conduits independent of the Glycol Feed Unit. 3.5 FIELD QUALITY CONTROL: A. The CSP shall: 1. Verify that systems and equipment have been properly cleaned, flushed, and filled with water, and are fully operational before introducing operational chemicals for water-treatment systems. 2. Introduce and maintain chemical treatment to achieve the specified performance requirements. 3. Submit a written startup test report for each system placed into service. 4. Provide validation testing and required reports. 5. Attend final on-site system turn over meeting with Owner and Commissioner. Present final validation report demonstrating that performance requirements have been achieved and that each system is currently properly treated. 3.6 COMMISSIONING: A. Perform Commissioning activities per Related Sections above. SPEC EDITOR: CONSULT WITH THE U-M DESIGN MANAGER TO DETERMINE IF TRAINING IS DESIRED FOR YOUR PARTICULAR PROJECT; KEEP OR DELETE OR MODIFY THE ARTICLE BELOW ACCORDINGLY. BuildingName The Description of the Project P00000000 0000 Issued for:BID 232513 – - 12 3.7 OWNER TRAINING A. CSP shall train Owner's maintenance personnel on equipment operation, adding and maintaining proper chemical levels, troubleshooting, servicing and preventative maintenance procedures. Do not conduct training until after start up and commissioning is completed. Provide training using documents including the Program Administration Manual and the approved Operations and Maintenance manuals. Provide these documents to the Owner at least two weeks prior to the training to allow sufficient time for review. 1. Provide 2 hours training minimum. B. Schedule training at least 7 days in advance, at date and time approved by Owner.

END OF SECTION 232513

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SECTION 23 05 00

COMMON WORK RESULTS FOR HVAC SYSTEMS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. This Section is to coordinate with and be complementary to the General Conditions, General Requirements and Supplemental General Requirements, wherever applicable to Mechanical and Electrical Work.

B. Section 21 00 00 - Special Requirements for Mechanical and Electrical Work shall apply.

1.2 DESCRIPTION OF WORK INCLUDED

A. Work Included:

1. The work includes providing all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the owner, all Heating, Ventilating and Air Conditioning work as shown on the drawings and hereinafter specified, including, but not limited to the following:
   a. All motor starters, variable frequency drives and controllers for equipment furnished by this contract. Packaged type units shall be furnished completely prewired with panels mounted on the units as specified. All other motor starters and controllers will be turned over to the Electrical Contractor for installation and wiring.
   b. Two Chilled Water Hot Water Heating Ventilation Air Unit, complete with, supply fan, variable frequency drives, filters, dampers and controls.
   c. Fans — Inline fans, propeller fans etc.
   d. Hot Water Cabinet and unit heaters.
   e. Steam Condensate pumps.
   l. Hot water specialties such as expansion tanks, air vents, air separators, reducing and safety valves, etc.
   m. Accessories such as V-belt drives, flow measuring devices, draft gauges, machinery guards, thermostats, pressure gauges.
   n. Water treatment for hot water systems.
   o. Piping, fittings, and valves.
   p. Sheet metal ductwork and accessories such as dampers, access doors, etc.
   q. Registers, grilles and diffusers with access doors.
   r. Fire dampers, Combination smoke and smoke dampers with access doors. All Power & control wiring by this contractor.
   s. Installation of smoke detectors in ductwork.
   t. Pipe, duct and equipment insulation.
   u. Electric unit heaters.

v. Temperature Control: A complete electric/electronic system of temperature control shall be installed in connection with the HVAC systems, including all thermostats, damper motors and dampers for the outdoor air intakes and fan discharges. All control wiring for automatic temperature controls, including interlocking wiring for fans, pumps, etc. by this Contractor.
w. Painting and pipe identification for all work by this Contractor is previously specified under "Special Requirements for Mechanical and Electrical Work".
x. Test and balancing.
y. Piping sleeves, pipe inserts and anchor bolts, escutcheons, etc., as hereinafter specified.
z. Identification, name plates, tags and charts.
aa. Cutting and rough patching.
bb. Furnishing and setting of electric motors.
cc. Furnishing of starters, motor control centers and motor control devices as specified under "Special Requirements for Mechanical and Electrical Work".
dd. Templates and anchor bolts for equipment bases.
ee. Concrete pads for all HVAC work.

1.3 WORK INCLUDED UNDER OTHER SECTIONS OF THE SPECIFICATIONS

A. The following work is included under other Sections of the Specifications:

1. Framed openings as shown on the Drawings.
2. Floor and funnel drains adjacent to equipment requiring same will be furnished and installed by the Plumbing Contractor.
3. Outside air inlets, exhaust outlets, louvers and screens through walls, and elsewhere as noted on the Drawings. Motorized dampers furnished and installed under this Contract.
4. Power wiring for all motors except where otherwise noted.
5. Temporary heat and ventilation.
6. Setting of access doors furnished by this Contractor.
7. Undercutting of doors or louvers in doors.
8. All motor disconnect switches, except where in combination starters and where otherwise noted.
9. Finish painting.
10. Access doors in ceiling and walls.
11. Finish patching.
12. Ventilating hoods - kitchen, etc.
13. Wiring of aquastats, pressure controls in power circuit of cabinet and unit heaters.
14. Fan shutdown system.
15. Mounting of all starters, motor control centers, starter panelboards, and motor control devices: Division 16.
16. Packaged terminal unit enclosures.

1.4 QUALITY ASSURANCE

A. Perform work in accordance with quality established in Section 21 00 00 "Special Requirements for Mechanical and Electrical Work", and hereinafter specified. All work performed shall comply with local codes.

1.5 SUBMITTALS

A. General**:** Unless indicated otherwise in the specific technical section, if a particular product specified in the technical section is being provided, manufacturer's qualifications and samples (except as listed below), are not required to be submitted. Manufacturer's product data, installation instructions, samples requiring color or texture approval, samples showing thickness and type of material, shop drawings, and calculations are to be submitted. Schedules, startup manuals, operation and maintenance manuals, and shop drawings are always required to be submitted.

B. The following Submittals are required for all Sections of Division 23-Heating, Ventilating, and Air Conditioning. Specific "Supplemental Submittals" or additional information to that listed below that are required to be submitted are defined in each individual technical section.

1. Product Data: Submit manufacturer's product data for equipment including catalog sheets or cuts, specifications, capacity, performance charts, test data, materials, dimensions, weights, furnished specialties and accessories; and installation instructions. Submit start-up instructions where applicable.
2. Shop Drawings: Submit manufacturer's shop drawings detailing equipment assemblies and indicating dimensions, weight, loadings, required clearances, method of field assembly, components, location and size of each field connection.

C. Where indicated in the Supplemental Submittals of the technical sections, the following submittals are defined as follows:

1. Maintenance Data: Submit maintenance data and parts list. Include this data and the product data in the maintenance manual.
2. Test Report: Submit factory certified test results prior to shipping.
3. Certificates: Submit written affidavit stating that the Contractor has started up and demonstrated that the equipment is operating properly as designed.

D. Piping, Ductwork, and Wiring Diagrams: Submit a complete wiring diagram, ductwork layout, and piping layout of all equipment. All parts of the installation shall be indicated exactly as installed and shall be properly identified. HVAC Identification and all piping shall be clearly shown and labeled.

E. Coordination Drawings: Provide complete coordination Drawings showing interface of all mechanical trades with the Architecture of the Building. All copies are to be signed. The Contractor is to keep a copy of the signed coordination drawing on the site.

F. Miscellaneous Submittals

1. HVAC Painting Schedule: Provide a complete schedule of all items to be painted.

1.6 ACCESSIBILITY

A. Install access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of access panels and doors. Allow ample space for removal of all parts that require replacement or servicing.

B. Extend all grease fittings to an accessible location.

C. For access doors to valves, dampers and all other HVAC type of items, accessories and equipment, concealed in walls, furrings and hung ceilings; Refer to Section 08305. Door shall permit full access to the equipment.

D. Per Sections FGC 306.7 of the 2014 NYS Fuel Gas Code and Section MC 304.13, equipment and appliances installed on rooftops of buildings shall be installed in accordance with the requirements of the Section FC 504.4 of the 2014 New York State Fire Code regarding rooftop access and obstructions, and shall not obstruct or interfere with firefighting operations or the operation of any doors, windows, fire escapes, or other means of egress or other building components requiring operation or access. Layout and coordinate equipment and piping in a manner that will not affect the required access.

E. Per Sections MC 306.1 and FGC 306.1, appliances shall be accessible for inspection, service, repair and replacement without disabling the function of a fire-resistance-rated assembly or removing permanent construction, other appliances, venting systems or any other piping or ducts not connected to the appliance being inspected, serviced, repaired or replaced. A level working space at least 30” deep and 30” wide shall be provided in front of the control side to service an appliance. Clearance shall also be provided as required by the New York State Electrical Code.

F. Per Section MC 1004.3, clearances shall be maintained around boilers, generators, heaters, tanks and related equipment and appliances so as to permit inspection, servicing, repair, replacement and visibility of all gauges. When boilers are installed or replaced, clearance shall be provided to allow access for maintenance and repair per the boiler’s listing and manufacturer’s installation instructions. Passageways for inspection around all sides of boilers shall have an unobstructed width of not less than 18” unless the boiler’s listing or department approval or manufacturer’s installation instructions state otherwise.

1.7 MECHANICAL INSTALLATIONS

A. Coordinate HVAC equipment and materials installation with other building components.

B. Verify all dimensions by field measurements.

C. Arrange for chases, slots, and openings in other building components to allow for HVAC installations.

D. Coordinate the installation of required supporting devices and size of sleeves to be set in poured concrete and other structural components as they are constructed.

E. Sequence, coordinate, and integrate installations of HVAC materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning and entrance prior to the close of the building.

F. Coordinate the cutting and patching of building components to accommodate the installation of HVAC equipment and materials.

G. Where mounting heights are not detailed or dimensioned, install HVAC services and overhead equipment to provide the maximum headroom possible.

H. Install HVAC equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting and minimum of interference with other installations.

I. Coordinate the installation of HVAC materials and equipment above ceilings with suspension system, light fixtures, and all other installations and accessories.

J. Provide all rigging, disassembly and reassembly of equipment including the furnishing and installation of dunnage and all other required and necessary accessories. Supports for ductwork/pipes/etc. supported by the roof deck shall utilize manufactured supports or pipes that will permit effective roofing. Use of irregular shaped units such as strut channels is not permitted.

K. For purposes of clearness and legibility, HVAC Drawings are essentially diagrammatic, and size and location of equipment are drawn to scale wherever possible. The Drawings indicate size, connection points and routes of ductwork and pipe. It is not intended, however, that all offsets, rises and drops are shown. Provide ductwork and piping as required to fit structure, avoid obstruction, and retain clearances, headroom openings and passageways. Piping/ductwork installed over any means of egress and access passageways must be 7’-6” clear inclusive of insulation.

1. Location of items passing through roofing/ waterproofing membranes shall be in strict accordance with recommendations of the NRCA (National Roof Contractors Association) Manual to allow for proper flashing of items, including, but not limited to, the following:
   a. No penetrations shall be made within 12” of any walls, parapets, roof curbs, expansion joints or any other projections (clear distance between penetration or equipment curb face shall be 12” minimum).
   b. Provide manufactured curb chases where multiple small pipes enter at one location.
   c. Piping/ductwork/equipment supports that penetrate membranes shall be round or square/rectangular to allow proper flashing. Use of “kindorf” type supports is not permitted to penetrate membranes.
2. Piping/ductwork at equipment must be done in a manner such that access around equipment is not impeded, such as at equipment platforms.

1.8 COORDINATION DRAWINGS

A. Provide coordination drawings. Coordination drawings shall be completed in accordance with the CPM Schedule so as not to delay the progress of the Project, for example, the installation of any floor slab in which the placing of mechanical equipment (sleeves, inserts, conduits, and all other accessory items) is involved. The HVAC contractor shall cooperate with the P&D, Fire Protection Systems, and Electrical contractors in the development of the coordination drawings. Drawings shall be submitted prior to installation of the MEP systems.

1. For boiler replacement projects, the boiler room coordination plans are required to be submitted before the start of construction.

B. The coordination drawings shall be prepared in the following manner: The HVAC contractor shall prepare a set of CADD drawings drawn to the scale of 3/8"=1'-0", indicating thereon mechanical equipment, ductwork, steam and return piping, hot and/or chilled water piping, refrigerant piping, fuel oil and diesel piping, plus structural and architectural background details. The HVAC contractor shall deliver this set of mylars (or CAD drawings) to the Plumbing and Drainage contractor, who will draw the P&D work to scale on the coordination drawings. Then the HVAC Subcontractor shall deliver the coordination set to Fire Protection Systems contractor, who shall superimpose the Fire Protection work on the drawings. Then the HVAC Subcontractor shall deliver the set of mylars (or CAD drawings) to Electrical contractor, who shall superimpose the Electrical work on the drawings. The elevation, location, support points, seismic restraint locations, load imposed on the structure at support and at the seismic restraint location, anchor points, and size of all lines shall be indicated. All beam and slab/deck penetrations shall be indicated, and sizes shall be coordinated with the structural steel and metal deck shop drawings. HVAC Contractor shall provide shop drawings for all roof deck openings required for installation of HVAC systems. Roof and floor slab/deck opening shop drawings shall be dimensioned from the centerline of the nearest structural column and coordinated with the approved HVAC equipment, sheet metal shop drawings, structural steel and metal deck framing plan, etc. The specified order in which the Subcontractors impose their work on the coordination drawings is not intended to grant priority to any one trade contractor in the allocation of space. At the completion of this phase, hold a coordination meeting to eliminate any interference among the trades that the drawings indicate and to avoid any conflicts in installing the Work. Should any problems of coordination require architectural or structural change of design, this change shall be submitted to the Owner for approval.

C. If any trade installs any Work before coordinating with the Work of other trades, that Trade shall make necessary changes to correct the condition without extra cost to the Owner. This requirement for "Coordination Drawings" shall not be construed as authorization to make any unauthorized changes to the Drawings. All Design Drawings space allocations shall be maintained, such as ceiling height, chase walls, equipment room size, and all other items and accessories, unless prior written authorization is received from the Owner to change them.

D. After the set of mylars (or CAD drawings) have been coordinated, and all necessary changes have been made, each Subcontractor shall sign the coordination drawings, attesting to the agreement that the work is clear.

E. Furnish (in writing, with copies to the Engineer) any information necessary to permit the Work to be installed satisfactorily and with the least possible interference or delay.

1.9 CUTTING AND PATCHING

A. Do not endanger or damage installed Work through procedures and processes of cutting and patching.

B. Arrange for repairs required to restore the work, because of damage caused as a result of HVAC installations.

C. No additional compensation will be authorized for cutting and patching Work that is necessitated by defective or non-conforming installations.

D. Perform cutting, fitting, and patching of HVAC equipment and materials required to:

1. Remove and replace defective work.
2. Remove and replace work not conforming to requirements of the Contract Documents.
3. Remove samples of installed work as specified for testing.
4. Install equipment and materials in existing structures.
5. Cut, remove and legally dispose of selected HVAC equipment, components, and materials as indicated, including, but not limited to removal of HVAC piping, heating units and trim and other HVAC items made obsolete by the new work.
6. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

E. Locate, identify, and protect HVAC services passing through remodeling or demolition area and serving other areas required to be maintained operational. When transit services must be interrupted, provide temporary services for the affected areas.

1.10 ELECTRICAL CHANGES TO MECHANICAL EQUIPMENT

A. If any changes made in equipment submitted are approved especially as to the sizes of the motors, notify Electrical.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Handle equipment carefully to prevent damage, breaking, denting, and scoring. Do not install damaged units or components; replace with new.

B. Store equipment in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

C. Comply with manufacturer's rigging and installation instructions for unloading equipment, and moving them to final location.

PART 2 - PRODUCTS

2.1 SPARE PARTS

A. Hot water pumps - For each pump listed, unless otherwise specified:
   1. One set of wearing rings.
   2. One set of bearings.
   3. One set of packing glands complete with rings, nuts and bolts.
   4. Three gaskets for casing joint.
   5. Sufficient stuffing box packing for four packings.

B. Where pump specifications do not require packing glands of stuffing boxes, spares listed may be omitted.

C. Filters:

   1. The Contractor shall furnish a minimum of two complete spare filter sets for the filters for all units.

D. Miscellaneous Spare Parts:

   1. Water column glasses shall be provided for each tank utilizing one.
   2. One complete set of gaskets shall be provided for each of the following pieces of equipment:
      a. All manhole and handhole openings for the expansion tank.
      b. Converters (hot water).

   3. Furnish one complete set of V-belts for each belt driven unit installed.

2.2 LIST OF MANUFACTURERS

A. The manufacturer's name appearing first on this list is the manufacturer the project design was based upon. However, the additional manufacturers listed herein are also acceptable with the provision that they meet the requirements of these Specifications, ratings, and/or space allocations listed in the Specifications or shown on the Drawings.

   1. Boilers
      a. Viessmann Manufacturing Co. (Vitocrossal 200 and 300 series)
      b. Fulton Heating Solutions, Inc. (Endura+)
      c. Aerco International (BMK Series)
      d. BBT North America Corp. Buderus) (SB625WS, SB745WS Series)
      e. Lochinvar (CREST)
      f. Cleaver Brooks (Clearfire Model CFC)
      g. or equal

2. Combustion Controls and Boiler Control Panels
   a. Viessmann
   b. Hays Corp.
   c. Bailery Meter Co.
   d. Hagan Div. of Westinghouse
   e. or equal

3. Condensate Pump
   a. Federal Pump Corp.
   b. Dunham Bush
   c. or equal

4. Chiller
   a. Daikin
   b. Trane
   c. York
   d. Carrier
   e. Or equal

5. Automatic Stop Check Valves
   a. Crane Co.
   b. Edwards Valve Mfg. Co.
   c. or equal

6. Water Pumps (Base Mounted)
   a. Bell & Gossett
   b. Peerless
   c. Weiman
   d. Paco
   e. or equal

7. Water Pumps ln-Line
   a. Bell & Gossett
   b. Armstrong
   c. Thrush

8. Packaged Air Conditioning Units
   a. Daikin
   b. Trane
   c. Johnson Controls York
   d. Carrier
   e. or equal

9. Air Filters
   a. American Air Filter Farr

b. Cambridge
c. or equal

10. Draft Gauges
    a. Dwyer
    b. or equal

11. Inline and Roof Exhaust Fans
    a. Loren Cook
    b. Greenheck
    c. Peerless
    d. Buffalo
    e. ACME
    f. or equal

12. Laundry Exhaust Ventilator
    a. Enervex
    b. Wing
    c. Quickdraft

13. Propeller Fans
    a. Loren Cook
    b. Greenheck
    c. Peerless
    d. Buffalo Forge
    e. ACME
    f. or equal

14. Cabinet & Unit Heaters
    a. Vulcan
    b. Trane
    c. Sterling
    d. Dunham-Bush
    e. or equal

15. Convectors
    a. QMARK
    b. Vulcan
    c. Trane
    d. Sterling
    e. or equal

16. Expansion Tanks
    a. Bell & Gossett
    b. Adamson

c. Buffalo

17. Water Specialties
    a. Bell & Gossett
    b. Taco
    c. or equal

18. Expansion Joints
    a. Zallea
    b. Flexonics
    c. or equal

19. Thermometers & Pressure Gauges
    a. Ashcroft
    b. U.S. Gauge
    c. Trerice
    d. Weiss Instruments

20. Motors
    a. General Electric
    b. Westinghouse
    c. Allis Chalmers
    d. or equal

21. Starters, Motor Control Centers, Switches
    a. General Electric
    b. Westinghouse
    c. Cutler-Hammer
    d. or equal

22. Diffusers, Registers & Grilles
    a. Titus
    b. Anemostat
    c. Carnes

23. Valves
    a. Walworth
    b. Jenkins
    c. Crane
    d. or as specified under paragraph on "Valves".

24. Insulation and Acoustic Lining
    a. Johns Manville
    b. Owens-Corning Fiberglas Corp.
    d. CSG Snap-on

e. or equal

25. Vibration Isolation

a. Mason Industries
b. Vibration Eliminator Co.
c. Korfund Corp
d. or equal

26. Water Treatment
a. Heating Economy Services, Co., Inc.
b. Astro Pak Corp.
c. Okite Chemical Corp.
d. Drew Chemical Corp.

27. Internal Cleaning & Treating of Piping
a. Heating Economy Services Co., Inc.
b. Astro Pak Corp.
c. Okite Chemical Corp.
d. Drew Chemical Co.

PART 3 – EXECUTION

3.1 INSPECTION

A. Contractor shall examine location where these specialties are to be installed and determine space conditions and notify Architect in writing of conditions detrimental to proper and timely completion of the work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install equipment in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

B. Support: Install equipment on 6" high concrete pad when installed on floor, with vibration isolators and restraints as required.

C. Accessories: Install equipment accessories not installed at factory and shown on the Drawings.

D. Connections: Connect all equipment and accessories as recommended by manufacturer for a complete installation.

E. Contractor shall not leave sharp exposed metal edges (bottom of threaded rods, mechanical equipment supports, etc.) that could otherwise present safety hazards to the building's occupants/work staff.

F. All penetrations made into other trades work are to be sealed to air tight/watertight condition. Ensure that all penetrations into ductwork have been sealed so that they are air tight. Access doors shall be of such construction as to make an air-tight seal that will pass duct work pressure testing. Penetrations through insulated systems, such as refrigerated rooms/equipment, etc, shall be insulated and sealed on both sides of penetration. Sealant on interior side of such insulated spaces/equipment shall be silicone recommended by manufacturer.

3.3 ADJUSTING AND CLEANING

A. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.3 FIELD QUALITY CONTROL

A. Upon completion of installation of HVAC Specialties, test HVAC Specialties to demonstrate compliance with requirements. When possible, field correct malfunctioning units, then reset to demonstrate compliance. Replace units which cannot be satisfactorily corrected.

END OF SECTION 23 05 00

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SECTION 23 05 10

HVAC SPECIALTIES

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. This Section is to coordinate with and be complementary to the General Conditions, General Requirements and Supplemental General Requirements, wherever applicable to Mechanical and Electrical Work.

B. Section 21 00 00 - Special Requirements for Mechanical and Electrical Work shall apply.

1.2 DESCRIPTION OF WORK

A. The Work includes providing of all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all HVAC Specialties as shown on the Drawings and hereinafter specified.

1.3 QUALITY ASSURANCE

A. Firms regularly engaged in manufacture of this equipment with characteristics and capacities required, whose products have been in satisfactory use in similar service for not less than ten (10) years.

B. Provide products produced by the manufacturers, which are listed in Section entitled “Approved Manufacturers List”.

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

1.4 SUBMITTALS

A. Refer to Section 21 00 00 – Special Requirements for Mechanical and Electrical Work and submit shop drawings.

1.5 COORDINATION

A. Refer to Section 21 00 00 – Special Requirements for Mechanical and Electrical Work and submit shop drawings.

1.6 GUARANTEE

A. Refer to Section 21 00 00 – Special Requirements for Mechanical and Electrical Work and submit shop drawings.

PART 2 - PRODUCTS

2.1 THERMOMETERS

A. Furnish and install, where indicated on the Drawings and where specified herein, separable well-type dial or 9" Organic Liquid adjustable angle type in glass stem, thermometers as manufactured by American, Trerice, Weksler, Weiss or approved equal.

B. All thermometers shall be installed in such a manner as to cause a minimum of restriction to flow in the pipes and so that they can easily be read from the floor.

C. Dial thermometers shall be 5 inches hermetically sealed, bimetal with stainless steel cases, antiparallax dials with raised jet-black figures, stainless steel stems, and brass separable sockets unless otherwise specified. Thermometers for duct mounting shall have union connections in lieu of separable sockets. Separable wells shall be standard type for uninsulated pipe and logging extension type of proper length for insulated pipe. Stem shall extend a minimum of 2 1/2" into the fluid.

D. The accuracy of all thermometers shall be within 1% of the scale range.

E. All instrument wells for controls and indicators furnished by the temperature control manufacturer shall be installed under this Section

F. Where conditions are such that thermometers would not be readable from the floor, remote bulb dial thermometers shall be mounted on panelboards. The thermometers shall be 5-inch dials and shall be vapor actuated. The thermometers shall have separable wells. Panel mounted thermometers shall be provided with an engraved nameplate mounted below each thermometer to identify its service. The nameplates shall be chrome plated with black filled letters.

G. A thermometer shall be installed in the hot water inlet and outlet of each hot water supply and return mains at each building. Additional thermometers shall be installed where indicated on the Drawings.

H. The scale range for the thermometers shall be as follows:

Service	Temperature Range	Remarks
Hot Water	30° to 300° F	

2.2 PRESSURE GAUGES

A. Furnish and install where indicated on the Drawings and where specified herein, Bourdon spring type pressure gauges as manufactured by U.S. Gauge, Weksler, Trerice, Marsh, Ashcroft, or approved equal.

B. All gauges shall be installed to be easily readable from the floor. Where conditions are such that gauges on piping would not be readable from the floor, the gauges shall be installed on panelboards.

C. The gauges shall have dull, black enamel cast aluminum casings with chrome plated bezels or rims. The gauges shall have white faces with black filled engraved numerals and adjustable pointer. The diameter of the dial shall be not less than 4½ inches. Gauges shall have brass bronzed brushed rotary type movement.

D. Panel mounted gauges shall be designed for flush mounting with back connections and shall be provided with an engraved nameplate mounted below each gauge to identify its service. The nameplates shall be chrome plated with black filled letters.

E. Differential pressure switches, pressure sensing pipe taps, furnished by temperature control manufacturers shall be installed under this Section.

F. The accuracy of all gauges shall be within 1% of the scale range.

G. All gauges on water lines shall be fitted with filter type pressure snubbers consisting of 3/8" dia. x 1/8" thick, micro metallic stainless-steel fibers, as manufactured by Operating and Maintenance Specialties or approved equal. All gauges on steam lines shall be fitted with pigtails.

H. A pressure gauge shall be installed in the suction and discharge of each hot water. Additional pressure gauges shall be installed where indicated on the Drawings.

I. The scale range of pressure gauges shall be as follows:

Service	Pressure Range
Hot Water	0 to 100 psig.
Discharge side of Water Pressure Reducing Valve	0 to 100 psig.

J. All other pressure gauges shall have a range at least twice the working pressure, but in no case less than 0 to 30 lbs. A ball valve shall be installed on the water side of each gauge. A needle valve shall be installed on the system side of each steam gauge.

2.3 MACHINERY GUARDS

A. Moving parts of machinery exposed to contact by personnel shall be guarded by barrier to a type which complies with OSHA Code.

B. Exposed moving parts such as belts and couplings shall have not less than ¾" No. 16 gauge metal guards with all edges rounded and gauge, material and construction shall be in accordance with OSHA standards – paragraphs 7173.3, 7173.5 and 7174.1. Guards shall have 1-1/4" x 11/4" x 1/8" angle iron frame properly supported.

C. All machinery guards covering the ends of motor or equipment shafts shall have openings for the insertion of a tachometer. Machinery guards shall be painted with two coats of machinery gray enamel.

2.4 EXPANSION TANKS

A. Furnish and install as shown on the Drawings, Pressurized Diagram Type Expansion Tanks. It shall be air pre-charged to the initial fill pressure of the system. It shall be suitable for a maximum working pressure of 125 psi and shall be furnished with ASME stamp and certification papers. It shall have a sealed-in elastomer diaphragm suitable for an operating temperature of 240° F. (Manufacturer to be furnished with saddles for horizontal installation).

2.5 AIR VENTS

A. In installing water piping systems and all equipment, carefully plan the actual installation in such a manner that high pints and air pockets are kept to a minimum and are properly vented where they are unavoidable. All air elimination devices called for on the Drawings and in these Specifications shall be provided and properly installed. In addition, furnish and install all other air elimination devices which may be required due to job conditions. Assume responsibility for a proper, continuous and automatic air elimination to assure even and balanced distribution of water to all equipment.

B. Furnish and install an Armstrong No. 1 AV or Sarco 13W automatic air vent with test petcock at each high point in the water piping mains and where indicated on the Drawings. Furnish and install a 125 psig rated valve on the system side of each automatic air vent. Vents on hot water, chilled water lines shall have Hoke Fig. No. PY-271 valves or approved equal. Vents on hot water, chilled water lines shall have Hoke Fig. No. RB-271 valves or approved equal.

C. Furnish and Install manual air vents Hoffman No. 500 or approved equal, for all upfed radiation. Furnish and install a 125 psig rated ball valve on the system side of each manual air vent. Provide access to all air vents.

2.6 AIR SEPARATORS

A. Furnish and install the air separators for water system where indicated on the Drawings. The separators shall be Rolairtrol, as manufactured by Bell and Gossett or equal as approved by the Architect.

B. The units shall be of ASME construction and shall be stamped 125 psig W.P.

C. The units shall be furnished without integral strainers.

D. The units shall be installed in strict accordance with the manufacturer's recommendations.

E. The units shall be supported on 2" pipe legs and shall be provided with a ¾" drain gate or ball valve with hose end and cap.

2.7 V-BELT DRIVES

A. All V-belt drives furnished under this Section shall be Gates Rubber Co., Woods, or approved equal. Drives shall be designed with an overload factor of twice the fan brake horsepower but in no case less than 125% of motor horsepower rating. Machined cast iron pulleys shall be used. Manufacturer's shop drawings shall state actual transmission capacity of each drive. Provide companion sheaves for adjustable sheave drives. Companion sheaves shall be selected such that the individual belts shall not exceed a two-degree misalignment of the groove centerlines between the driving and driven sheaves. Sheaves shall be complete with flanges and locking devices. All sheaves shall be selected with a 1.5 minimum service factor.

B. Provide matching belts.

C. All motors shall have variable speed drives.

2.8 STRAINERS FOR WATER SYSTEM

A. Furnish and install a full-size Y-pattern strainer on the inlet of each control valve and each water pump & where indicated in the Drawings.

B. The strainers shall be as manufactured by Spence, Sarco, Barnes and Jones, Elliott, Crane or Mueller.

C. All strainers, except where otherwise noted, shall have bronze body up to 2", semi-steel above 2-1/2", rated at 126 psig for all systems with 50 psig max. pressure and 250 psig for all others. Strainers 2-inch diameter and smaller shall have screwed ends. Strainers 2-1/2-inch diameter and larger shall have flanged ends.

D. All strainers shall have removable cylindrical or conical screens of brass construction. They shall be designed to allow blowing out of accumulated sediment and to facilitate removal and replacement of the screen without disconnecting the main piping. E. Screens for water 1/16" for 3" inclusive, 1/8" for 4" and above.

F. An approved blow-out connection with gate valve shall be made to each strainer. The valves shall be located not higher than 8 feet above the floor. All drain connections shall be piped to floor drains.

2.9 REDUCING AND SAFETY VALVES FOR WATER SYSTEM

A. Furnish and install pressure reducing and safety valves for makeup water systems and where indicated on the drawings.

B. The reducing valve shall be Model 7 pressure reducing valve with field adjustable setting as manufactured by Bell & Gossett or equal as approved by the Architect.

C. The valves shall be made by Bell and Gossett or approved equal and shall have 150 pound raised face flange on the inlet and discharge for all sizes 2-1/2" and above, 2" and below shall be screwed.

D. The safety valves shall be steel valves with stainless steel trim. The bonnet shall be enclosed and equipped with a packed lifting lever. The spring shall be carbon steel rated for 450° F.

E. The vertical discharge line from the safety valves shall be installed as close to the safety valves as possible and piped to drain.

2.10 PRESSURE AND TEMPERATURE TEST STATIONS

A. Furnish and install in each supply and return runout to each heating coil, each cooling coil and where indicated on the Drawings, a ¼" MPT fitting to receive either a temperature or pressure probe 1/8" OD. Fitting shall be solid brass with valve core of Nordel (Mac. 275° F.), fitted with a color coded and marked cap with gasket, and shall be rated at 1000 psig.

B. In addition, the installing contractor shall supply the Owner with six pressure gauge adapters with 1/8" OD probe and 6 five-inch stem pocket testing thermometers: six 50-500°F for hot water.

C. Provide one pressure and temperature test kit consisting of one 0-60 PSI, water pressure gauge and one 0-30 psi water pressure gauge each with No. 500 gauge adapter attached, a 25-125°F. pocket testing thermometer, a 0.220 F. pocket test thermometer, a No. 500 gauge adapter, and a protective carrying case. Provide one additional 0-60 psi pressure gauge and one additional 0-30 psi pressure gauge.

D. Test kit shall be turned over to the Facility upon completion of project.

E. Test stations and test kit shall be manufactured by Paterson Engineering Company, Inc. or approved equal.

2.11 REFRIGERATION ACCESSORIES

A. Refrigerant Filter-Dryer: Provide, refrigerant filter-dryers. Refrigerant filter-dryers shall be replaceable core "Catch All" type, as manufactured by Sporlan Valve Company.

B. Moisture and Liquid Indicator: Provide combination liquid and moisture indicators type "See All", as manufactured by Sporland Valve Company.

C. Flexible Pipe Connections: Provide flexible pipe connections. Flexible pipe connectors to be all bronze construction, metal braided type suitable for Refrigerant 22.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordination: Where identification is to be applied to surfaces that require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

B. Ductwork Identification:

1. Identify air supply, return, exhaust and intake ductwork with duct markers or painted identification materials and provide arrows showing ductwork service and direction of flow, in black or white (whichever provides most contrast with ductwork color).
2. Location: In each space where ductwork is exposed, or concealed only by removable ceiling system, locate signs near points where ductwork originates or continues into concealed enclosures (shaft, underground or similar concealment), and at 50' spacings along exposed runs.
3. Access Doors: Provide plastic duct markers on each access door in ductwork and housings, indicating purpose of access (to what equipment) and other maintenance and operating instructions, and appropriate safety and procedural information.
4. Concealed Doors: Where access doors are concealed above acoustical ceilings or similar concealment, provide plastic labels installed on the exposed white iron adjacent to the acoustical ceiling tile that when removed will provide access to the access door. Provide plastic duct marker on the door itself as described in 3 above.

C. Piping System Identification: Install pipe markers and color bands and include arrows to show direction wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.

1. Near each valve and control device
2. Near each branch, excluding short take-offs for terminal units; mark each pipe at branch, where there could be question of flow pattern.
3. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.
4. Near major equipment items and other points of origination and termination.
5. Spaced intermediately at maximum spacing of 50' along each piping run, except reduce spacing to 25' in congested areas of piping and equipment.
6. On piping above removable acoustical ceilings except omit intermediately spaced markers.

D. Underground Piping Identification: During back-filling/top-soiling of each exterior underground piping system, install continuous underground-type plastic line marker, located directly over buried line at 6" to 8" below finished grade. Where multiple small lines are buried in common trench and do not exceed overall width of 16", install single line marker.

E. Valve Identification:

1. Provide valve tag on every valve, cock and control device in each piping system; exclude check valves, valves within factory-fabricated equipment units, and shut-off valves at HVAC terminal devices and similar rough-in connections of units. List each tagged valve in valve schedule for each piping system.
   a. Tagging Schedule: Comply with requirements of "Valve Tagging Schedule" at end of the Section.
2. Mount valve schedule on frames located in machine rooms where indicated or, if not otherwise indicated, where directed by the Owner.
3. Where more than one major machine room is shown on the Project, mount valve schedule in each major machine room, and repeat only main valves which are to be operated in conjunction with operations of more than single machine room.

F. A permanent factory-applied name-plate(s) shall be affixed to appliances on which shall appear in legible lettering, the manufacturer's name or trademark, the model number, serial number and the seal or mark of the approved agency. A label shall also include the following:

1. Electrical equipment and appliances: Electrical rating in volts, amperes and motor phase; identification of individual electrical components in volts, amperes or watts, motor phase; Btu/h output; and required clearances.
2. Absorption units: Hourly rating in Btu/h; minimum hourly rating for units having step or automatic modulating controls; type of fuel; type of refrigerant; cooling capacity in Btu/h; and required clearances.
3. Fuel-burning units: Hourly rating in Btu/h; type of fuel approved for use with the appliances; and required clearances.
4. Electric comfort heating appliances: Name and trade-mark of the manufacturer; the model number or equivalent; the electric rating in volts, ampacity and phase; Btu/h (W) output rating; individual marking for each electrical component in amperes or watts, volts and phase; required clearances from combustibles; and a seal indicating approval of the appliance by an approved agency.

G. Mechanical Equipment Identification:

1. Install plastic equipment marker near each major item of mechanical equipment and each operational device, as specified herein if not otherwise specified for each item or device in their respective sections. Provide signs for the following general categories of equipment and operational devices
   a. Main control and operating valves, including safety devices
   b. Meters, gauges, thermometers and similar units
   c. Strainers, filters, humidifiers, water treatment systems, thermostatic traps and similar equipment
   d. Primary balancing dampers, mixing boxes

2. Provide permanent factory-applied name-plate(s) for all appliances including but not limited to the following:

   a. Fuel-burning units including boilers, furnaces and heaters units
   b. Pumps, compressors, chillers, condenser and similar motor-driven units

c. Converters, heat exchangers, coils, evaporators, heat recovery units and similar equipment
d. Fans, blowers and VAV terminals
e. Packaged HVAC central-station, zone-type units, heat pumps, air handling units, heating and ventilating units
f. Tanks and pressure vessels

3. Plastic equipment marker lettering Size: Minimum 1/4" high lettering for name of unit where viewing distance is less than 2', 1/2" high for distances up to 6', and proportionally larger lettering for greater distances. Provide secondary lettering 2/3 to 3/4 of size of principal lettering.

4. Text of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

5. Optional Use of Plasticized Tags: At the Owner's option, where equipment to be identified is concealed above acoustical ceiling or similar concealment, plasticized tags shall be installed within concealed space to reduce amount of text in exposed sign (outside concealment).

a. Operational valves, dampers and similar minor items located in non-occupied spaces (including machine rooms) shall be identified by plasticized tags.

6. Key Identification Tag: Provide an identification tag on each and every key provided under this project and deliver to the Custodian or Building Manager. Follow the valve tagging schedule specified herein for the numbering.

H. Concealed Equipment, Dampers, Access Doors, etc.

1. Equipment (e.g. VAV boxes), dampers, access doors, filters, etc. concealed above the hung ceiling shall have plastic labels placed on the white iron of the hung ceiling before the ceiling tiles are installed to allow easy location of the devices once the hung ceiling is installed.
2. Devices shall be labeled by type and the number utilized on the final approved drawings to identify the device (if item is numbered).

END OF SECTION 23 05 10

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SECTION 23 05 23

DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. This Section is to coordinate with and be complementary to the General Conditions, General Requirements and Supplemental General Requirements, wherever applicable to Mechanical and Electrical Work.

B. Section 21 00 00 - Special Requirements for Mechanical and Electrical Work shall apply.

1.2 DESCRIPTION OF WORK

A. The work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all Valves as shown on the drawings and hereinafter specified.

1.3 QUALITY ASSURANCE

A. "Manufacturers" - Firms regularly engaged in manufacture of valves, whose products have been in satisfactory use in similar service for not less than 10 years.

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

C. Provide valves whose performance under specified conditions, is certified by the manufacturer.

1.4 SUBMITTALS

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work and submit shop drawings.

1.5 SUPPLEMENTAL SUBMITTALS

A. Product Data: Submit manufacturer's product data including valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, required clearances and installation instructions.

B. Shop Drawings: Submit valve schedule showing manufacturer's figure number, location, and valve features for each required valve. Include list indicating valve and its application in the schedule.

C. Maintenance data:

1. Maintenance manuals

D. Maintenance Material:

1. Provide one plug valve wrench for every ten plug valves sized 2" and smaller, minimum of one. Provide wrench and set screw for each plug valve sized 2½" and larger.
2. Padlock and two (2) keys for each lock.

1.6 GUARANTEE

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work.

PART 2 - PRODUCTS

2.1 VALVES

A. Valves- General: All valves shall be of a design which the manufacturer lists for the service and shall be of materials allowed by the latest edition of the ASME Code for pressure piping for the pressure and temperature contemplated, unless a higher grade or quality is herein specified. All valves shall be of the same manufacturer, except for special applications.

B. The system shall be supplied with valves in all branch mains and risers, at all pumps, tanks, reducing and control valves, heating and cooling surfaces and at all apparatus; so located, arranged and operated as to give complete shut-off. Except where flanged valves are used, each connection to equipment shall be made with screwed or flanged unions on the equipment or discharge side of the valve.

C. All valves shall be installed with the best workmanship and are to have neat appearance and be arranged so that they are easily accessible.

D. Each valve shall have the maker's name or brand, the figure or list number and the guaranteed working pressure cast on the body or stamped on the bonnet, or shall be provided with other means of easy identification.

E. Check valves installed in the horizontal position shall be swing checks; valves installed in the vertical position shall be silent checks for 2-1/2" and above, and lift check for 2" and smaller, except that all check valves in pump discharges shall be silent checks.

F. Provide blow-off valves at all strainers, and where shown on the Drawings.

G. Provide valve operating chain on all gate, globe, butterfly and plug valves in Mechanical Equipment Rooms - 4" and larger, which are more than 7'-0" above the operating floor. Unit shall be complete with adjustable sprocket, chain and guide (Crane "Babbit" type). Provide hook to keep chain out of the way.

H. Generally, all valves are to be of the gate type, except that globe valves shall be used for throttling services and on traps, and pressure reducing and control valve bypasses. Globe valves used on bypasses shall have monel metal mountings. Pumps shall have triple-duty valves on discharge piping.

I. All valves 2 inches in diameter and smaller shall be all bronze with bronze bodies. Valves 21/2 inches in diameter and larger shall have iron bodies with bronze mountings (except where otherwise noted).

J. All flanged-end valves shall have renewable metal seat rings and discs. On gate valves these parts shall be of bronze, on all globe valves they shall be of bronze and suitable for throttling service.

K. All screwed-end globe valves shall be of the union bonnet type with renewable Teflon discs.

L. All valves shall have their bonnets back-seated to provide for packing under pressure. All gate valves shall be of the solid tapered wedge type.

M. Drain valves shall be provided on tanks, receivers, risers and where they may be required or necessary, for draining the lines and equipment. Drain valves or plug cocks shall be provided at the low points for proper drainage. Cocks and valves shall be provided with threaded ends for those connections.

N. All valves up to 2 inches in diameter shall have screw ends, 2-1/2 inches in diameter and over shall have flanged ends. Valves 2-1/2" and larger which are non-rising stem, shall have position indicators.

O. All bronze and iron valves shall be furnished with Teflon impregnated packing.

P. All handwheels shall be of malleable iron.

Q. No Asbestos shall be used in construction of valves including the gaskets.

R. All valves shall be of type and number as specified below: For all services, except as otherwise noted.

TYPE	SIZE	CRANE NO.	JENKINS NO.	WALWORTH NO.	REMARKS
Gate Valve	2” & Smaller	428UB	47U	2	150 lb. WSP, Bronze, Rising Stem
	2-1/2”& Larger	465-1/2	651C	726F	125 lb. WSP, Bronze Trimmed, Iron Body, OS & Y
Globe Valve	2”& Smaller	14-1/2P	546P	237P	300 lb. WSP, Bronze
	2-1/2”& Larger	351	613C	906F	125 lb. WSP, Bronze Trimmed, Iron Body, OS&Y
Angle Valve	2” & Smaller	16-1/2	558P	238P	300 lb. WSP, Bronze
	2-1/2”& Larger	353		907F	125 lb. WSP, Bronze Trimmed, Iron Body, OS&Y

Swing Check	2" & Smaller	137	409Z	406	150 lb. WSP, Bronze
	2-1/2"& Larger	373	624	M928F	125 lb. WSP, Bronze Trimmed, Iron Body
Silent Check	All Sizes				Williams-Hager, Fig. 636, 125 lb. WSP, Semi-Steel
Drain Valve	2"& Smaller	451 (2/4" size only)	372N	24	200 lb.OWG, non-rising stem, Hose end, Bronze with Bronze Cap & Chain
Blow-Off Valve	2"& Smaller		124		300 lb. WSP, Bronze Y-Type

S. Valves for radiation service shall be as follows:

T. Hot Water Radiation Shut-off All sizes, 200 psi water, Cerci Fig. 2251

U. Radiation Balancing - All sizes, 200 psi water, bronze, male union outlet, Cerci type IBW

TYPE	SIZE	CRANE NO.	JENKINS NO.	WALWORTH NO.	REMARKS
Gate Valve	2" & Smaller	634E	270U	47 or 48	300 lb. WSP, Rising Stem
	2-1/2"& Larger	7-1/2"E	204	786F	250 lb. WSP, Iron Body, OS & Y
Globe Valve	2"& Smaller	382P	556P	260P	300 lb. WSP, Bronze
	2-1/2"& Larger	21E	923	955F	250 lb. WSP, Iron Body, OS&Y
Check Valve	2" & Smaller	76E	762A	428	300 lb. WSP, Bronze
	2-1/2"& Larger	39E	339R	970F	250 lb. WSP, Iron Body

2.2 VALVES IN COPPER TUBING

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

TYPE	SIZE	CRANE NO.	JENKINS NO.	WALWORTH NO.	REMARKS
Gate Valve	2" & Smaller	1320			125 lb. WSP, Bronze
Globe Valve	2"& Smaller	1310			125 lb. WSP, Bronze
Angle Valve	2" & Smaller	1311			125 lb. WSP, Bronze
Swing Check	2" & Smaller	1303		406SJ	125 lb. WSP, Bronze
Balancing Valves	All Sizes				See Balancing Cocks
Full Port Ball Valve	All Sizes	F9202			125 lb. WSP, Bronze

2.3 REFRIGERANT VALVES

A. All refrigerant valves shall be silver brazed joint as follows:

1. Globe Valves - 1-1/8" O.D. and smaller: pickles, Henry type 626; 1-3/8" O.D. and larger: packed, wing cap, Henry type 203.

2. Angle Valves - 1-1/8" O.D. and smaller: pickles, Henry type 647 and 642; 1-3/8" O.D. and larger: packed, wing cap, Henry type 216.

3. Check Valves - 7/8" O.D. and smaller: brass, Henry type 116A; 1-1/8" O.D. and larger: bronze, Henry type 205.

4. Charging and Purging Valves - Line valve, Henry type 623; angle valve, Henry type 643.

5. Relief Valves - Angle type, brass, Henry type 52.

6. Gate Valves - All sizes: Globe Valves.

2.4 LUBRICATED PLUG VALVES

A. Full port opening tapered plug suitable for lubrication under service pressure with plug in any position.

B. Lubricating Guns:

1. One for every 10 valves.

2. Extra heavy, lever type, hydraulic hand gun.

3. 15,000 psi gauge and 12" long connection hose.

4. Similar to Walworth #1699 or approved equal. C. Lubricant:

1. Manufacturer's recommendations.

2. One year supply, each valve. D. Operators:
   a. 4" to 6", wrench, except as noted.
   b. Wrench set for each size valve.
   c. Wrench for every 10 valves, each size
   d. 8" and larger: gear operated.
   e. Permanently installed handwheel.

2.5 TRIPLE DUTY VALVE

A. Furnish and install as shown on plans, a triple duty valve designed to perform the functions of a non-slam check valve, throttling valve, shutoff valve and calibrated balancing valve, as manufactured by Bell and Gossett.

B. The valve shall be of heavy-duty cast iron construction with NPT connections per ANSI B1.20.1-83 suitable for 175 psi working pressure for sizes 2" and smaller and 125 psi ANSI flanged connections suitable for 175 psi working pressure for sizes 2 2 and above. The valve shall be fitted with a bronze seat, replaceable bronze disc with EPDM seat insert, stainless steel stem, and chatter preventing stainless steel spring. The valve design shall permit repacking under full system pressure.

C. The valve shall be equipped with brass readout valves (with integral check valve) to facilitate taking differential pressure readings across the orifice for accurate system balance.

2.6 READOUT METER FOR TRIPLE DUTY VALVES

A. Provide a portable Readout Meter with provision for hanging, capable of indicating pressure differential across a system component. Unit to be complete with all necessary hoses, shut-off and vent valves, and carrying case. Reading range to be 0-100. Readout kits to be ITT Bell and Gossett Model #R0-2.

B. Readout kit shall be used by the balancing Contractor to balance the systems and then it shall be turned over to the Fund.

2.7 TRUMPET VALVE ASSEMBLY

A. Furnish and install a 4-port trump valve assembly for each pump piped with 1/4" O.D. copper tubing as indicated in the drawings.

B. The gauge on the trumpet valve assembly shall be accurate to 1%. Case shall be 4 1/2 in.

C. diameter, stem mounted, heavy steel with screwed ring and unbreakable crystal. Pressure indicator shall have recalibrator, compound scale calibrated both in pounds and feet from full vacuum to selected pressure, and quick set dial for pressure comparison. Maximum indicator pressure shall at least equal pump shut off head (when system pressure is at relief valve setting) and shall exceed this minimum by no more than 50 psi.

D. Trumpet valve shall be spring return pushbutton manifold of rugged brass construction with ports connection to system at indicated points and with a test port connection to system at indicated points and with test port connection for calibration.

E. Trumpet valve system shall be attached to system piping with heavy bracket and convenient height to permit easy push button operation and dial observation.

F. Unit shall be a Flow Conditioning Corp. 4-port Trumpet Valve Hydronic Indicator System or approved equal.

2.8 VALVE CONSTRUCTION

A. Piping less than 100 psi: 200# WOG Class, cast iron body.

1. Up to 2": screwed

2. 2-1/2" and larger: flanged, USAS 300#.

3. Similar to following: Walworth figure numbers:

Class	4"	5" & 6"	8" & 12"	14" up
200#	1700F	1705F	1727F	1703F

2.9 CIRCUIT SETTERS PLUS BALANCING VALVES WITH READOUT PORTS AND MEMORY STOP

A. Typical Specification

1. Furnish and install as shown on plans with manufacturers recommendations Model CB calibrated balance valves by Bell & Gossett.

B. Pre-Set Balance Feature

1. Valves to be designed to allow installing contractor to pre-set balance points for proportional system balance prior to system start-up in accordance with pre-set balance schedule.

C. Valve Design and Construction

1. All valves V2" to 3" pipe size to be of bronze body/brass ball construction with glass and carbon filled TFE seat rings. Valves to have differential pressure read-out ports across valve seat area. Read-out ports to be fitted with internal EPT inserts and check valves. Valve bodies to have 1/4" NPT tapped drain/check purge ports. Valves to have memory

stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position. All valves to have calibrated nameplates to assure specific valve settings. Valves shall be designed for positive shut-off.

D. Design Pressure/Temperature

1. 1/4" — 3" NPT connections 300 psig (2069 kPa) at 250°F (121°C). 2.10. BALL VALVES

E. Ball Valves up to 2" may be used for all water services as an alternate to gate valves, and globe valves.

F. Ball valves shall be bronze body, bronze ball and stem, Teflon seats and seals threaded ends, 400 psig cold W.O.G. Worchester No. 411T-SE or equal. "APOLLO" 70 - 100 Series.

PART 3 - EXECUTION

3.1 INSPECTION

A. Contractor shall examine location where valves are to be installed and determine space conditions and notify architect in writing of conditions determined to proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Except as otherwise indicated, comply with the following requirements:

1. Install valves where required for proper operation of piping and equipment including valves in branch lines where necessary to isolate sections of piping. Locate valves so as to be accessible and so that separate support can be provided when necessary.
2. Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane unless unavoidable. Nonrising stem valves shall be used only where headroom prevents full extension of rising stems. Install valve drains with hose-end adapter for each valve that must be installed with stem below horizontal plane.
3. Install gate valves for shut-off; to isolate equipment, parts of systems, and vertical risers and any banked system of coils and to separate each coil.
4. Hose gate valves: Provide hose gate valves to drain the pipe at the low points of the system.
5. Install globe for throttling service and control device.
6. Use tapered lubricated plug valves in water systems for throttling service and at the discharge of all pumps. Use nonlubricated plug valves only when shut-off or isolating valves are also provided.
7. Provide tapered lubricated 1" drain gate valves at main shut-off valves, and at all low points of piping and apparatus.

8. Provide 1" gate vent valves at all high points in the piping system.
9. Provide lift check valves at the discharge of all pumps as shown on the Drawings
10. Outside Screw and Yoke Type: Gate valves in lines leading from the boilers to the boiler steam header, in boiler blow-off lines, and at other points so specified or shown on the Drawings shall have outside screw and yoke (OS&Y) with bronze rising stem.

B. Insulation: Where insulation is indicated, install extended-stem valves, arranged in proper manner to receive insulation.

C. Mechanical Actuators: Install mechanical actuators with chain operators where indicated on the Drawings. Extend chains to about 5'6" on the floor and hook to clips to clear aisle passage.

3.3 ADJUSTING AND CLEANING

A. Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.

B. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.4 MINIMUM VALVE REQUIREMENTS

A. Shutoff valves shall be installed on the supply and return side of all heat exchangers.

B. Shutoff valves shall be installed on the building supply and return of central utility systems and district heating and cooling systems.

C. Shutoff valves shall be installed on the connection to any pressure vessel.

D. Shutoff valves shall be installed on both sides of a pressure-reducing valve.

E. Shutoff valves shall be installed on connections to mechanical equipment and appliances. This requirement does not apply to components of a hydronic system such as pumps, air separators, metering devices and similar equipment.

3.5 FIELD QUALITY CONTROL

A. Upon completion of installation of valves, test valves to demonstrate compliance with requirements. When possible, field correct malfunctioning valves, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected.

END OF SECTION 23 05 23

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SECTION 23 05 48

VIBRATION & SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. This Section is to coordinate with and be complementary to the General Conditions, General Requirements and Supplemental General Requirements, wherever applicable to Mechanical and Electrical Work.

B. Section 21 00 00 - Special Requirements for Mechanical and Electrical Work shall apply.

1.2 DESCRIPTION OF WORK

A. Provide a complete system of vibration isolation and seismic bracing for each item of HVAC piping, ductwork, and equipment as specified herein and as needed for a complete and proper installation. Provide bracing for the equipment as shown on the Drawing Schedules. Product specific requirements are contained herein.

B. All equipment, piping, and ductwork as noted in the specification shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.

C. All isolators and isolation materials shall be of the same manufacturer and shall be certified by the manufacturer.

D. It is the intent of the seismic portion of this specification to keep all mechanical building system components in place during a seismic event and to prevent the release of hazardous or flammable materials contained within building mechanical systems.

E. All such systems must be installed in strict accordance with the seismic codes, component manufacturers' and building construction standards. Whenever a conflict occurs between the manufacturers' and construction standards, the most stringent shall apply.

F. This specification is considered to be the minimum requirements for seismic consideration and is not intended as a substitute for more stringent national, state, or local construction requirements.

G. The work in this section includes, but is not limited to the following:

1. Vibration isolation and seismic bracing for piping and ductwork
2. Equipment isolation bases
3. Flexible piping and ductwork connections
4. Seismic bracing for isolated equipment

5. Seismic bracing for non-isolated equipment

1.3 QUALITY ASSURANCE

A. Firms regularly engaged in manufacture of this equipment with characteristics and capacities required, whose products have been in satisfactory use in similar service for not less than ten (10) years.

B. Provide products produced by the manufacturers which are listed in Section "Approved Manufacturer's List".

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

1.4 SUBMITTALS

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work and submit shop drawings.

1.5 COORDINATION

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work.

1.6 GUARANTEE

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work.

1.7 TECHNICAL REQUIREMENTS

A. All mechanical equipment shall be mounted in accordance with the specifications below and for the specific requirements shown in the equipment schedule.

B. The isolation manufacturer shall supply all unit isolators, complete rails, fan and motor bases and structural steel forms for concrete inertia blocks, where called for and shall be responsible for the selection of all vibration eliminators and shall guarantee to meet the requirements of these Specifications.

C. Wherever rotational speed is mentioned as the disturbing frequency, the lowest such speed in the system shall be used. All isolation devices shall be selected for uniform static deflections according to distribution of weight. Lateral motion of all isolators shall be 1/4" maximum during start-up and shut-down.

D. "Outdoor" isolators, steel parts other than galvanized springs and cadmium plated springs shall be suitably coated to resist corrosion. Isolators shall be equipped with limit stops to resist wind velocity.

E. All fan units and air handling units (except fans with wheels under 27") shall be isolated as follows:

1. Up to 450 RPM: 75% efficiency (3-1/2" maximum deflection)
2. 450 RPM to 850 RPM: 90%
3. 850 RPM and over: 95%

F. Submittals shall show disturbing frequency, required efficiency, designed deflection and outside diameter of springs, when pertinent.

G. All horizontal pipe runs within the mechanical equipment room area, but not less than 50 feet from connected equipment shall be isolated from building structure by means of units designed for insertion in rods (Type D, 1.5 inch deflection).

H. For seismic restraint requirements, see Section 15050.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATION

A. Mountings:

1. Type A:
   a. Double deflection neoprene mountings shall have a minimum static deflection of 0.35. All metal surfaces shall be neoprene covered to avoid corrosion and have friction pads both top and bottom, so they need not be bolted to the floor.
   b. Bolt holes shall be provided for those areas where bolting is required. On equipment such as small vent sets and close coupled pumps, steel rails shall be used above the mounts to compensate for the overhang.
   c. Manufacturer/Type:
   Mason Industries, Inc.: ND or Rails RND Vibration Eliminator
   Co.: T44 or D-Rails

2. Type B:
   a. Spring isolators shall be free-standing and laterally stable without any housing and complete with 1/4" neoprene acoustical friction pads between the base plate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment.
   b. 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 deflection.
   c. Submittals shall include spring diameters, deflections, compressed spring height and solid spring height.
   d. Manufacturer/Type:
   Mason Industries, Inc.: SLFH, on rails type ICS Vibration Eliminator Co.OSK

3. Type C:
   a. Equipment with operating weight different from the installed weight such as chillers, boilers, etc., and equipment exposed to the wind such as cooling towers, shall be mounted on spring mountings as described under. Type "B" of this paragraph, but a housing shall be used that includes vertical resilient limit stops to prevent spring extension when weight is removed. The housings shall serve as blocking during erection and cooling tower mounts shall be located between the supporting steel and roof or the grillage and dunnage. The installed and operating heights shall be the same. A minimum clearance of 1/2" shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring action. Limit stops shall be out of contact during normal operation. Mountings used out of doors shall be hot dipped galvanized.
   b. Manufacturer/Type:
      Mason Industries, Inc. SLR Vibration Eliminator Co.
      KW

4. Type D:
   a. Vibration hangers shall contain a steel spring and a double deflection neoprene element in series. Neoprene elements shall have a minimum deflection 0.35". The neoprene element shall be molded with a rod isolation bushing that passes through the hanger box sized to allow for 30/ misalignment. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection and be seated in a neoprene cup with an integral molded bushing that passes through the lower hanger box.
   b. Manufacturer/Type:
      Mason Industries, Inc. 30N Vibration Eliminator Co.
      SNRC-30

5. Type E:
   (Not Used.)

6. Type F:
   a. Vibration hangers shall contain a double deflection neoprene element manufactured as an integral part of the element design to prevent short circuiting of the rod as it penetrates the housing body. Minimum static deflection shall be .35".
   b. Manufacturer/Type:
      Mason Industries, Inc. W30
      Vibration Eliminator Co. SNC

7. Type DE:
   (Not Used.)

8. Type G:
   a. Vibration isolator manufacturer shall furnish integral structural steel bases for both driver and driven machines.

b. Bases shall be rectangular in shape for all equipment other than centrifugal refrigeration machines and pump bases which may be "tee" or "L" shaped. Pump bases for split case pumps shall include supports for suction and discharge base ells. All perimeter members shall be WE 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.

c. Bases shall be WE bases as manufactured by Mason Industries, Inc. or approved equal.

d. Manufacturer/Type:

Mason Industries, Inc.	30N	Vibration Eliminator Co.	SNRC-30

9. Type E:

(Not Used.)

10. Type F:

a. Vibration hangers shall contain a double deflection neoprene element manufactured as an integral part of the element design to prevent short circuiting of the rod as it penetrates the housing body. Minimum static deflection shall be .35".

b. Manufacturer/Type:

Mason Industries, Inc.	W30
Vibration Eliminator Co.	SNC

11. Type DE:

(Not Used.)

12. Type G:

a. Vibration isolator manufacturer shall furnish integral structural steel bases for both driver and driven machines.

b. Bases shall be rectangular in shape for all equipment other than centrifugal refrigeration machines and pump bases which may be "tee" or "L" shaped. Pump bases for split case pumps shall include supports for suction and discharge base ells. All perimeter members shall be WE 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.

c. Bases shall be WE bases as manufactured by Mason Industries, Inc. or approved equal.

13. Type H:

a. 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.

b. Members shall be sufficiently rigid to prevent strains in the equipment.

c. Inverted saddles shall be ICS as manufactured by Mason Industries, Inc. or approved equal.

14. Type J:

a. Vibration isolator manufacturer shall furnish structural 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 shall be a minimum of 1/10 of the longest span, but not less than 6" or greater than 14". Forms shall include minimum concrete reinforcement consisting of 1/2 on 6" centers running both ways and a layer 1-1/2" above the bottom and a top layer of reinforcing steel as above for all bases exceeding 120" in one direction. Isolators shall be set into pocket housings which are an integral part of the base construction and set at the proper height to maintain a 1" clearance below the base. Bases shall be furnished with templates and anchor bolt sleeves as part of this system.

c. Manufacturer/Type:
Mason Industries, Inc. KIPWF Vibration Eliminator Co. SN Frames

15. Type Y:
(Not Used.)

16. Type R:
(Not Used.)

B. ISOLATION SCHEDULE:

	Vibration Eliminator Specification Type for Equipment Location:	
Type of Equipment	With No Occupied or Unoccupied Below	Above or below Occupied or Unoccupied Spaces
Pumps:		
Through 5HP	Type A (Rail Type) (0.4” deflection)	Type B (Rail Type) (1.0” deflection) 7.5
HP thru 30HP	Type G-B (0.4” deflection)	Type J-B (1.0” deflection)
Factory Assembled, Air Handling Equipment & PTAC Units:		
Suspended Units	Type D (1.5” deflection)	Type D (2.0” deflection above 600 rpm)
Floor Mounted Units & Return Fans External Spring Vibration Isolation	Type B (1.0” deflection)	Type B (2.0” deflection above 600 rpm) Type B-H (2.5” deflection below 650 rpm)

Type of Equipment	With No Occupied or Unoccupied Below	Above or below Occupied or Unoccupied Spaces
Class I Fans (Arrangement 1 & 3)		
Floor Mounted:	Type B-G (1.0” deflection)	Type B-G (2.0” deflection above 600 rpm) (3.0” deflection below 600 rpm) (4.0” deflection below 400 rpm)
Suspended:	Type F (1.5” deflection)	Type F (2.0” deflection)
Class I Fans (Arrangement 9)		
Floor Mounted:	Type B (1.0” deflection)	Type B (2.0” deflection)
Suspended:	Type F (1.5” deflection)	Type F (2.0” deflection)
Outdoor Fan Utility Fans:		Type G-C (2.0” deflection)

2.2 FLEXIBLE CONNECTIONS

A. Where shown on the drawings, provide a flexible pipe connector at pumps, and other vibrating equipment.

B. Flexible connector shall be:

1. Manufacturer of nylon tire cord and EPDM, both molded and cured with hydraulic presses.
2. Straight connectors to have two spheres reinforced with a mold-in external ductile iron ring between spheres.
3. Elbow shall be long radius reducing type.
4. Rated 250 psi at 170°F. Dropping in straight line to 170 psi at 250°F. for sizes 11/2" to 12". Elbows shall be rated no less than 90% of straight connections.
5. Sizes 10" and 12" to employ control cables with neoprene end fittings isolated from anchor plates by means of 1/2" bridge bearing neoprene bushings.
6. Minimum safety factor, 4 to 1 at maximum pressure ratings.
7. Submittals to include test reports.
8. Mason Type MFTNC Superflex, or approved equal.

PART 3 - EXECUTION

3.1 PREPARATION

A. For vibration isolation and seismic bracing equipment installed indoors, all metal parts, including rails and bases, shall be painted at the factory with one coat of primer paint and one coat of aluminum paint. Other means or rust resisting painting may be accepted, subject to prior approval.

B. Vibration isolation and seismic bracing equipment installed outdoors shall have all steel parts hot dipped galvanized, all bolts cadmium plated, and all springs cadmium plated and neoprene coated.

3.2 INSPECTION AND COORDINATION

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

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

C. Coordinate work with other trades to avoid rigid contact with the building. Inform other trades following work, such as plastering or electrical, to avoid any contact which would reduce the vibration isolation.

D. Bring to the Architect's attention, prior to installation, any conflicts with other trades which may result in unavoidable rigid contact with equipment or piping as described herein, due to inadequate space or other unforeseen conditions. Corrective work necessitated by conflicts after installation shall be at the responsible Contractor's expense.

E. Bring to the Architect's attention, any discrepancies between the Specifications and field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the Contractor's expense.

3.3 INSTALLATION

A. Mount floor-mounted equipment on 6" concrete housekeeping pads over complete floor area of equipment. Mount vibration isolating devices and related inertia blocks on concrete pad.

B. Each fan and motor assembly shall be supported on a single structural steel frame. Flexible duct connections shall be provided at inlet and discharge ducts.

C. The machine to be isolated shall be supported by a structural steel frame or concrete inertial base.

D. Brackets shall be provided to accommodate the isolator. The vertical position and size of the bracket shall be specified by the isolator manufacturer.

E. The minimum operating clearance between the equipment frame or rigid steel base frame and the housekeeping pad or floor shall be 1". Minimum operating clearance between concrete inertia base and housekeeping pad or floor shall be 2".

F. The equipment structural steel or concrete inertia base shall be placed in position and supported temporarily by blocks or shims, as appropriate, prior to the installation of the machine or isolators.

G. The isolators shall be installed without raising the machine and frame assembly.

H. After the entire installation is complete and under full operational load, the isolators shall be adjusted so that the load is transferred from the blocks to the isolators. When all isolators are properly adjusted, the blocks or shims shall be barely free and shall be removed. Isolation mounting deflection shall be (minimum) as specified or scheduled.

J. Install equipment with flexibility in wiring connection.

K. Verify that all installed isolator and mounting systems permit equipment motion in all directions. Adjust or provide additional resilient restraints to flexibly limit start-up equipment lateral motion to 1/4".

L. Prior to start-up, clean out all foreign matter between bases and equipment. Verify that there are no isolation short circuits in the base isolators or seismic restraints.

M. All piping and ductwork to be isolated shall freely pass through walls and floors without rigid connections. Penetration points shall be sleeved or otherwise formed to allow passage of piping or ductwork and maintain 3/4" to 1-1/4" clearance around the outside surfaces. This clearance space shall be tightly packed with firestopping or fiberglass and caulked airtight, after installation of piping or duct ductwork. Provide listed through penetration fire stop assembly at all piping penetrations of rated construction.

N. No rigid connections between equipment and building structure shall be made that degrades the noise and vibration isolation system herein specified.

O. The contractor shall not install any equipment, piping or conduit which makes rigid contact with the "building" unless permitted in this Specification. Building includes, but is not limited to, slabs, beams, columns, studs and walls.

P. Obtain inspection and approval of any installation to be covered or enclosed, prior to such closure.

Q. Diagonal thrust restraint shall be as described for Type D hanger with the same deflection as specified for the spring mountings. The spring element shall be designed so it can be pre-set for thrust and adjusted to allow for maximum of 1/4" movement at start and stop. Diagonal restraints shall be attached at the centerline of thrust. Restraint shall be Mason Type WB or approved equal.

3.4 VIBRATION ISOLATION OF DUCTWORK

A. All duct runs in all locations where a flexible connector cannot be utilized at the equipment (including but not limited to kitchen exhaust fans, lab exhaust fans, etc.) shall be isolated from the building structure by means of spring and neoprene hangers or spring mounted floor isolators. This isolation shall be for a distance of 50' from the connected equipment. Spring deflection shall be a minimum of 0.75".

3.3 PIPING ISOLATOR INSTALLATION

A. The isolators shall be installed with the isolator hanger box attached to, or hung as close as possible to, the structure.

B. The isolators shall be suspended from substantial structural members, not from slab diaphragm unless specifically permitted.

C. Hanger rods shall be aligned to clear the hanger box.

D. Vertical riser pipe supports and guides shall utilize neoprene elements (similar to Mason Type ADA).

E. Pipe sway braces, where required shall utilize two (2) neoprene elements.

3.4 FIELD QUALITY CONTROL

A. Upon completion of installation of all vibration isolation devices herein specified, the local representative of the isolation materials manufacturer shall inspect the completed system and report, in writing, any installation error, improperly selected isolation devices, or other faults in the system that could affect the performance of the system. Contractor shall submit a report to the Architect, including the manufacturer's representatives final report, indicating all isolation reported as improperly installed or requiring correction, and include a report by the Contractor on steps taken to properly complete the isolation work.

END OF SECTION 23 05 48

SECTION 23 05 93

ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. This Section is to coordinate with and be complementary to the General Conditions, General Requirements and Supplemental General Requirements, wherever applicable to Mechanical and Electrical Work.

B. Section 21 00 00 - Special Requirements for Mechanical and Electrical Work shall apply.

1.2 DESCRIPTION OF WORK

A. All piping and equipment shall be tested. Labor including standby electrician, materials, instruments and power required for testing shall be furnished unless otherwise indicated under the particular Section of the Specification.

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

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

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

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

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

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

H. All fans and duct systems shall be completely balanced by the adjustment of sheaves, dampers, registers and other volume and diverting control devices, to obtain the air quantities indicated on the design drawings. Replace sheaves if required to meet design conditions.

I. All pumps and piping systems shall be completely balanced by the adjustment of plug cocks, globe valves or other control devices, to obtain flow quantities indicated on the design drawings.

1.3 QUALITY ASSURANCE

A. Prior to installation of the mechanical systems, engage the services of an independent air and water balancing firm that shall be subject to the approval of the Architect. The firm shall have no affiliation with a mechanical contracting or sheet metal company. Balancing and testing company shall be a member of the Associated Air Balance Council. The balancing firm shall have at least one member of its full time staff who is a licensed professional engineer who shall supervise the balancing work. Prior to balancing, a list of instruments to be used shall be submitted to the Architect. All instruments shall be calibrated within six months before tests.

B. When all specified testing and balancing procedures have been completed, a written report shall be submitted to the Architect for review. The report shall be tabulated in standard AABC format. As part of the Architect's review process, the accuracy of the balancing report shall be field spot checked on a random basis, with the assistance of the balancing firm's project supervisor.

1.4 SUBMITTALS

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work submit all tests and balancing reports as described hereafter.

PART 2 - PRODUCTS

2.1 PATCHING MATERIALS

A. Unless otherwise shown on the Drawings, use same products as originally installed for patching holes in insulation, ductwork and housings that have been cut or drilled for test purposes, including access for test instruments, attaching jigs, and similar purposes.

PART 3 - EXECUTION

3.1 INSPECTION

A. Do not proceed with adjusting and final balancing until unsatisfactory conditions have been corrected in a manner approved by the balancing specialist and the Owner.

B. Examine the air systems to see that they are free from obstructions. Determine that all dampers, grilles and registers are open, that moving equipment is lubricated, that clean filters are installed, pneumatic and automatic controls are functioning, and perform other inspection and maintenance activities necessary for proper operation of the systems.

C. Examine the hydronic and steam systems to see that they are free from abnormal obstructions, and that all piping, valves and equipment have been properly made fully operational. Determine that all equipment and control systems are performing correctly by functional testing.

3.2 FIELD TEST OF PIPING

A. During construction properly cap or plug all lines to prevent the entrance of sand, dirt, etc. The system of piping shall be blown through wherever necessary after completion (for the purpose of removing grit, dirt, sand, etc., from all equipment and piping), for as long a time as is required to thoroughly clean the apparatus.

B. Use anti-freeze solution for piping to be tested in winter.

C. All piping shall be tested as hereinafter specified. Tests shall be made after erection and before covering is applied or piping painted or concealed, and as sections of mains and groups of risers are completed. The extent of the work completed before pressure tests are made shall be determined by the Architect.

D. All piping, unless otherwise specified, shall be tested (for a period of eight (8) hours) to a hydrostatic pressure at least 1-1/2 times the maximum designed working pressure (but not less than 50 lbs. per square inch) for a sufficiently long time to detect all leaks and defects; and after testing shall be made tight in the most approved manner. Tests shall be repeated once after leaks and defects have been repaired. When automatic control valves, equipment and similar devices which are incapable of withstanding test pressures applied to piping, such devices shall be removed, or otherwise protected during tests. After approval of such tests, devices shall be installed and tested with operating medium to operating pressures. The following shall be tested for four consecutive hours and proved tight. Leaks shall be remedied by replacing defective work.

Hydrostatic Item	Field Test
Drain	50 psi
Steam and Condensate	100 psi
Hot water heating	100 psi
Chemical Treatment -Hot water	100 psi
Vent -Water discharge	100 psi
Chilled Water Piping	100 psi

E. Leaks appearing during the various pressure tests shall be corrected by replacing all defective materials or welds and subsequent tests shall be made until the piping is found perfect. Caulking of screwed joints or pending of welds is prohibited. Wherever it is necessary to cut out a weld and the ends of the pipe cannot be conveniently brought together, then a short piece of pipe shall be fitted in and welded as approved by the Architect.

F. Provide all other tests required by the Building Department, Fire Department and all other authorities having jurisdiction.

3.3 RUNNING TEST OF PIPING SYSTEMS

A. When directed, any section of the work, after it has been completed and otherwise satisfactorily tested, shall be put in actual operation and operated for a period of two (2) days of 24 hours each, during which time any defects which may appear shall be remedied and any adjustment which may be necessary shall be made.

B. During the time of the tests, repack all valves, make all adjustments and otherwise put the apparatus in perfect condition for operation, and instruct the Owner's representative in the use and management of the apparatus.

3.4 TEST OF REFRIGERATION PIPING

A. Refrigeration piping shall be tested in accordance with the recommendations of the refrigeration equipment manufacturer and in the following sequence for a period of 24 hours.

Triple Leak / Pressure Check Procedure

1. After the refrigerant piping installation is complete, open the isolation ball valves, if any, that may
have been included in the piping system.
2. Verify that both the liquid and gas (vapor) suction line outdoor unit service ports are closed, and
the stem head access caps are tight. The leak / pressure check is to be performed only to the refrigerant piping system and the connected indoor unit.
3. Remove the cap on the gas (vapor) suction line Schrader port. Connect the (medical-grade dry) nitrogen cylinder regulator to a gauge manifold, then connect the gauge manifold to the gas (vapor) suction Schrader port on the service port.
4. Perform the leak / pressure check at 150 psig for fifteen (15) minutes (standing pressure check).
5. Perform the leak / pressure check at 300 psig for thirty (30) minutes (standing pressure check).
6. Perform the leak / pressure check at 550 psig for one (1) hour to make sure the piping system is leak-free. After the gauge reading reaches 550 psig, isolate the system by first closing the gauge manifold, then close the nitrogen cylinder valve. Check the flared (and any brazed connections) for leaks by applying a bubble solution to all joints. No visible leaks, losses in pressure or increase in vacuum occur during test period.

3.5 EQUIPMENT TEST

A. Demonstrate that all equipment and apparatus fulfill the requirements of the Specifications and that all equipment shall be operated and tested for rated capacities and specified characteristics. Voltage and amperage readings shall be taken on all electric motors.

B. Operate dearation for 40 hours to demonstrate fans to operate at maximum capacity and for all variable volume dampers to be at the full open position.

C. Set the system up to operate with maximum return air and minimum outside air.

D. The following preliminary data should be obtained and recorded at the supply and return fans:

1. Fan and motor RPM.
2. Motor and current voltage.
3. Fan, coils and filter statics.
4. Nameplate data on the fans and motors.
5. Motor sheave, fan pulley and belt sizes.

E. Traverse the main supply ducts and return ducts to determine CFM deliveries of the fans.

F. Set the system to operate at 100% outside air and check the motor amperage. The motor amperage should remain relatively constant indicating no change in total air flow. If a change in flow does occur, adjust outside air, return air, and relief air dampers accordingly. Set enough variable volume controllers throughout the building to maximum in order to simulate a maximum load on the fan.

G. Measure the system duct static pressure at selected points throughout the system. Monitoring points shall be in those duct runs which are of the longest equivalent length (greatest friction loss). Monitor these points during the adjusting and balancing procedures to assure proper inlet static pressure is being maintained to the variable volume units.

H. Adjust the return fan to approximately 5% above design CFM and the supply fan to either 5% above design or to the point where the static pressure at the end of each branch is at required static pressure, whichever condition is reached first.

1. If the fan is adjusted to obtain the minimum static pressure, then it may be necessary to readjust the fan during the balancing as the static pressure will decrease as the constant volume controller deliveries are increased.

I. Make preliminary outlet readings and balance the outlets to design CFM and record all readings.

J. Individually set the controls for each variable volume damper to full heat the outlets.

K. Adjust the damper minimum position so the outlet total CFM is at the design minimum delivery. At the minimum delivery rate, the balance between the outlets may not hold, but no outlet adjustments should be made.

L. Adjust the outlets for design delivery.

M. The following final data should be obtained and recorded at the supply and return fans:

1. Fan and motor RPM.
2. Motor current and voltage.
3. Fans, coils and filter statics
4. Approximate motor sheave setting

N. Check the following controls:

1. Economizer system function, calibration, etc. All improperly operating items shall be promptly repaired or replaced and the tests shall be repeated until the particular system and component parts thereof receive the approval of the Architects.

3.6 AIR LEAKAGE TEST FOR DUCTWORK

A. All supply, return and exhaust ductwork shall be tested.

B. The testing of all joints for air leakage after erection and the repair of any leaks are positive requirements. Leakage must be kept to a specified minimum. The test for air leakage is divided into two phases; namely, testing of individual vertical risers and testing of all branches. Provide all required instruments.

C. Test shall be made at 2 inches water gauge static pressure (pressure leakage Class `B'). All risers, branches and runouts shall be tested after installation before insulation is applied and before the air mixing units are installed. The total allowable leakage for the entire system shall be no more than five (5) percent of the total system capacity.

D. Equipment necessary for performing this test shall include a rotary hand blower calibrated orifice section and a "U" tube gauge board complete with cocks and rubber tubing. The test hookup, as well as details for the fabrication of the orifice section shall be in accordance with the recommendation of the "HVAC Air Duct Leakage Test Manual" of Sheet Metal and Air Conditioning Contractors National Association, Inc.

3.7 TEST PREPARATION AND PROCEDURE

A. On initial startup, prior to any tests, check the rotation and running amperage of all fan and pump motors to prevent damage to equipment by overload.

B. Final balancing must be done with all systems completely installed and operating, and after the automatic temperature controls have had their final adjustment.

C. New, clean filters must be installed in all supply systems prior to balancing.

D. All water systems shall be completely filled and vented, and all strainers cleaned prior to balancing. Inspect expansion tanks for proper water level and operating of makeup water valves.

E. All main supply air ducts shall be traversed, using a pitot tube and manometer. The manometer shall be calibrated to read two significant figures in all velocity pressure ranges.

F. A main duct is defined as either of the following:

1. A duct serving five or more outlets.
2. A duct serving two or more branch ducts.
3. A duct serving a reheat coil.
4. A zone duct from a multizone unit.

5. A duct emanating from a fan discharge or plenum and terminating at one or more outlets.

G. The intent of this operation is to measure by traverse the total air quantity supplied by the fan and to verify the distribution of air to zones.

H. Submit data in support of all supply fan deliveries by the following four methods:

1. By summation of the air quantity readings at all outlets.
2. By duct traverse of main supply ducts.
3. By a rotating vane traverse across a filter or coil bank.
4. By plotting RPM and static pressure readings on the fan curve. Air density corrections must be indicated.

I. For return air and exhaust fans, summation and duct traversing shall be sufficient.

J. Inspect all fan scrolls and remove objects or debris. Inspect all coils and remove debris -or obstructions. Verify that all fire dampers are open.

K. The supply air systems shall be completely balanced prior to the final balancing of the water systems.

L. Upon completion of all air and water balancing, all duct dampers, plug valves and other throttling devices shall be marked in the final adjusted position.

3.8 AIR BALANCE

A. Record the following design requirements for all fans and fan motors from the approved shop drawings.

1. Air quantities - CFM
2. Approximate fan speed - RPM
3. Fan static pressure (total or external) - inches of water.
4. Maximum tip speed - FPM
5. Outlet velocity - FPM
6. Fan brake horsepower
7. Motor horsepower
8. Volts, phases, cycles and amps at design conditions.

B. Record the following data from all fans and fan motors installed at the project:

1. Manufacturer, model and size
2. Motor horsepower, service factor and RPM
3. Volts, phases, cycles and full load amps
4. Motor starter and heaters size
5. Equipment location

C. All fans and duct systems shall be completely balanced by the adjustment of sheaves, dampers, registers and other volume and diverting control devices, to obtain the air quantities indicated on

the Drawings. Outside air and return air modulating dampers shall be adjusted to admit the specified quantities of air under all cycles of operation. All final adjusted air quantities shall be within 10% of the design requirements. Replace sheaves if required to meet design conditions.

D. Record the following test data for all fans and motors installed at the Project at final balanced conditions:

1. Fan speed RPM.
2. Fan static pressure (external and total) inches of water.
3. Static pressure drop across all filters, dampers, coils and other items in the supply fan casings.
4. Motor operating amps.
5. Actual voltage
6. Fan CFM
7. Calculated brake horsepower.

E. Submit single line diagrams of all duct systems indicating all terminal outlets identified by number. Data sheets shall list all such outlets denoted by the same numbers, including the outlet's size, "K" factor, location, CFM and jet velocity.

F. Submit this data for all supply, return and exhaust air systems.

G. Adjust the outside air and return air dampers to admit the required amounts of air under both summer and winter cycles. Record and submit the outside, return and mixed air temperatures for both cycles after final adjustments.

H. Air balancing shall be performed with filters partially blocked to simulate a pressure drop across the filters equal to that midway between the clean and the dirty condition.

I. KITCHEN EXHAUST DUCTWORK

The main branch from each hood connected to the riser shall be balanced with setting of the fire & smoke damper in the correct open position to achieve desire air flow.

3.9 WATER BALANCE

A. Record the following design requirements for all pumps and pump motors from the approved shop drawings:

1. Water quantity - GPM
2. Total head - feet of water
3. Pump speed - RPM
4. Impeller size
5. NPSH (if required)
6. Motor horsepower
7. Volts, phases, cycles and amps at design conditions

B. Record the following data from all pumps motors installed at the project:

1. Manufacturer, model and size.
2. Impeller size
3. Motor horsepower, service factor and RPM
4. Volts, phases, cycles and full load amps
5. Motor starter and heaters size
6. Equipment location

C. All pumps and piping systems shall be completely balanced by the adjustment of plug cocks, globe valves or other control devices, to obtain the flow quantities indicated on the Drawings. Balancing shall be done with all controls set for full flow through coils. All automatic throttling valves shall be in the full-open position.

D. Record the following test data for all pumps and pump motors installed at the Project:

1. Pump speed - RPM
2. Total head at shut-off or dead-end discharge - feet of water. (Plot this value on pump curve as a verification of impeller size.)
3. Suction, discharge and total head at final adjusted flow - feet of water.

E. Balance the water flow through all coils, convertors, cabinet heaters, unit heaters, package terminal units, etc., in accordance with design requirements.

F. For all orifice plates, record the pipe size, orifice size, flow factor, required differential pressure, final differential pressure and calculated final flow quantity.

G. For all venturi type, pitot tube, or other flow measuring devices record the pipe size, manufacturer and size of device, and the direct reading or the differential pressure, and calculated final flow.

H. Flow shall be balanced through all equipment and coils by means of pressure drop. Obtain curves from the various manufacturers indicating the relationship between flow and pressure drop through the coils and equipment. Readings shall be taken on calibrated test gauges. Submit curves with the final report. All water terminal units can be balanced thru use of balancing valves with DP read-out ports.

I. Upon completion of the water balance, reconcile the total heat transfer through all coils by recording the entering and leaving water temperatures and the entering and leaving air dry bulb and wet bulb temperatures.

J. Upon completion of balancing adjust all differential bypasses and three-way valve bypasses for the same pressure drop or full bypass as on full flow.

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SECTION 23 07 00

PIPING INSULATION (HVAC)

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Provide thermal insulation on the piping (HVAC) required on this Project, as needed for a complete and proper installation; product specific requirements are contained here; Section 230100, General Provisions for Heating, Ventilating and Air Conditioning Work, shall be referred to for general requirements.

B. All insulation materials shall be free of asbestos.

1.02 RELATED SECTIONS

A Division 23 Sections

B. Division 26 Sections

C. Division 16 Sections

1.03 SUPPLEMENTAL SUBMITTALS

A. Schedule listing items to be insulated, description of insulation and finishing procedures

1.04 SUPPLEMENTAL QUALITY ASSURANCE

A. Installer's Qualifications: Firm with at least three years successful installation experience on projects with mechanical insulations similar to that required for this Project.

B. Code and Standards

1. Insulation characteristics: Pipe insulation installed in buildings shall conform to the requirements of the 2020 NYS Energy Conservation Code Section C403, shall be tested in accordance with ASTM E84 or UL 723 per Section NYSMC Section C403 and shall have a maximum flame spread index of 25 and a smoke developed index not exceeding 50. Insulation installed in an air plenum shall comply with Section MC. Section MC 602.2.1 requires that materials exposed within plenums shall be noncombustible or shall have a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E84 or UL 723 per NYS ECC Section C403.
Hydronic piping shall be insulated to the thickness required by the NYS Energy Conservation Code.

2. All insulation material shall be in accordance with the above ASTM E84 requirements or UL 723, using the specimen preparation and mounting procedures of ASTM E2231 per Section MC 604.3 or have OTCR approval.

3. Comply with ASTM, ASHRAE and New York State Energy Conservation Code Standards.

1.05 TEMPERATURE REQUIREMENT

A. Apply adhesive, sealers, coating, and all other items and accessories at the proper temperature as recommended by the manufacturer. If ambient conditions are not acceptable, provide temporary heat as required for proper installation without any delay to the Project completion.

1.06 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields

B. Coordinate clearance requirements with piping installer for insulation application. Establish and maintain clearance requirements for installation of insulation and any field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Approved Manufacturers:

Armacell LLC.
CertainTeed Corp.
Knauf Insulation
Johns Manville
The Dow Chemical Company (Building Materials)
Owens-Corning Fiberglas Corp. (including Owens Corning Evolution and VaporWick)
Pittsburgh Corning Corp.
Rubatex Corp.
3M VentureClad
Polyguard Products Inc.
Roxul
HITLIN Visionary Industrial Insulation

2.02 MATERIALS

A. Adhesives and Sealants for Insulation: All adhesives and sealants used on interior building insulation shall comply with the South Coast Air Quality Management District (SCAQMD)

Rule #1168; VOC limits shall comply with the limits indicated in Table 1 of LEED Version 3.0, Indoor Environmental Quality Section, Credit IEQ 4.1. Those limits correspond to an effective date of the SCAQMD Rule #1168 of July 1, 2005, and Rule Amendment date of January 7, 2005.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Foam insulation materials shall not use CFC or HCFC agents in the manufacturing process.

D. Hot Water/Chilled Water/Refrigerant Pipe Insulation

1. One-piece molded sectional fiber glass insulation made from inorganic glass fibers bonded with a thermosetting resin and shall have a nominal 4-pound density with a thermal conductivity (k) per Table C403.2.1 of the 2020 NYSECC. Insulations shall have factory-applied all-service jacket (ASJ) and adhesive used to adhere the jacket to the insulation. Insulation shall be suitable for use on piping up to 450ºF operating temperature.

2. Preformed polyisocyanurate closed cell insulation with a k-factor of 0.19 at 75ºF mean temperature and factory applied Polyvinylidene Chloride (PVDC) vapor retarder film for use in the chilled water supply and return lines and refrigerant lines.

3. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation made from inorganic glass fibers bonded with a thermosetting resin with absorbent cloth factory applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth. This type of wicking insulation shall be applied inside as an alternate to the cold piping (chilled water supply and return, refrigerant) systems.

4. All refrigerant pipe insulation located outside of the building above grade shall be elastomeric with UV protection as required by the insulation manufacturer.

E. High Temperature Hot Water Pipe Insulation

1. HTHW Piping systems installed in buildings and in tunnels shall be fully supported and insulated using mineral wool and metal jacket system as follows:

a. Conductivity of 0.22 and insulation thickness of 3” per the 2020 energy conservation code of New York State

b. Mineral Wool High Temperature Insulation: inorganic fibers derived from basalt volcanic rock with a thermosetting resin binder rated up to 1200ºF in accordance with ASTM C447. Maximum flame spread rating shall be 5 and smoke developed rating of 0 when tested in accordance with ASTM E84, UL723, CAN/ULC-S102-M. Mineral wool shall be rated as non-combustible in accordance with ASTM E136 and CAN4-S114-M. Mineral wool shall be fungi resistant in accordance with ASTM C1338. Mineral wool water vapor sorption shall be less than 1% by weight, less than 0.02% by volume at 120ºF and 95% RH in accordance with ASTM C1104.

c. Insulation shall be firmly applied in place with all joints butted tightly and mechanically fastened in place by wiring using 16-gauge nickel copper alloy or copper clad steel wire on maximum 6-inch centers. Stainless Steel or aluminum 0.016” thick roll jacketing shall be secured with 1/2" by 0.020” thick stainless steel or aluminum bands on maximum 12-inch centers. Fittings, valves, tees, flanges, connections, etc. shall be insulated with mitered segments of pipe insulation glued together with manufacturer approved adhesive and wired in place. These fittings then shall be covered with the roll jacketing.

F. Jackets

1. Factory-applied: ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip. For cold water pipe insulation, the jackets shall be the vapor barrier type, ASJ, PVDC.

2. PVC Plastic: one-piece molded type fitting covers and jacketing material (min of 20 Mil Thickness), gloss white. Connections: Tacks, pressure sensitive color matching vinyl tape.

3. For outdoor pipe insulation applications, jackets for insulation shall be made of 0.016" aluminum or stainless steel held with friction type, Z-locks, 12” apart. Per Section 6.4.4.1.1 of ASHRAE 90.1-13, insulation exposed to weather shall be suitable for outdoor service, e.g., protected by aluminum or sheet metal cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation that can cause degradation of the material.

4. For use over insulation on pipes operating at below-ambient temperatures at least part of the time or where a vapor barrier is required. ASTM C1136, Type II, is for use over insulation on pipes operating above-ambient temperatures or where a vapor retarder is not required.
   a. Field-applied jackets shall comply with ASTM C1136, Type I, unless otherwise indicated.

G. Insulation and accessories for valves, fittings, flanges etc. shall include the following:

1. One-pound density fiberglass blanket.

2. Segments of pipe insulation.

3. Pre-molded fiberglass fittings.

4. No. 20 gage galvanized steel or annealed wire.

5. Insulating cement.

6. In lieu of using coated pre-molded fittings for insulating fittings, valves etc., pre-molded 20-mil thick, high impact ultraviolet-resistant one-piece PVC fitting covers and precut insulation inserts are acceptable. For chilled water pipes and refrigerant pipes/tubing, the use of prefabricated insulation for valves, fittings, flanges etc. are acceptable. Bands, staples, tapes, wires, cements, adhesives, sealers and protective finishes: As specified herein or as recommended by insulation manufacturer for proper uses on piping insulations.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Before applying the insulation, all tests specified in Division 1 and Division 23 Sections should have been completed. However, thermal insulation can be applied to pipes prior to these tests providing that all fittings are left bare to permit detection and possible leaks.

3.02 SUPPLEMENTAL INSTALLATION

A. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance of tests.

B. 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.

C. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

D. Maintain integrity of vapor-barrier jackets on pipe insulation and protect to prevent puncture or other damage.

E. Valves shall be insulated up to packing unit.

F. Fire Seal Application: Where pipes pass through fire walls, fire partitions, fire rated pipe chase walls or floors above grade, insulation shall pass through and a UL classified assembly shall be provided. Refer to Section 078413 - Firestopping.

G. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.

H. The temperature of the jacket shall not exceed 200^{o}F.

I. Paper laminated jackets shall be permanently treated to retain the flame spread and smoke developed rating. Chemicals used for treating paper jacket laminates shall not be water-soluble and shall be unaffected by water and humidity.

J. Fiberglass insulation joints shall be sealed with butt strips that are compatible with the required facing. Stapling shall not be required to complete the closure. Manufacturer's data regarding thickness constraints in relation to operating temperature shall be followed. On cold systems, vapor barrier shall be provided. All penetrations and exposed ends of insulation shall be sealed with mold resistant vapor barrier mastic.

K. Insulation on all cold surfaces shall be applied with a continuous, unbroken vapor seal. Hangers, supports, anchors etc., that are secured directly to cold surfaces must be adequately insulated and vapor sealed to prevent condensation.

L. All surface finishes are to be extended to protect all surfaces, ends and raw edges of insulation.

M. General valves, fittings, etc. shall be insulated as follows:

1. For pipe sizes smaller than 4" wrap firmly under a minimum of a 3:1 compression, with 1-pound density fiberglass blanket, to a thickness equal to adjoining insulation. Secure with No. 20-gage galvanized or annealed steel wire. Finish with a smooth coat of insulating cement.

2. For pipe sizes 4" and larger, fit segments of pipe insulation equal in thickness to adjoining insulation and secure with No 20-gage galvanized or annealed steel wire. Finish with a smooth coat of insulating cement.

3. In lieu of the foregoing methods, the use of pre-molded fiberglass fittings of the same thickness of adjoining pipe insulation will be accepted. Finish with a smooth coat of insulating cement.

4. In lieu of the foregoing methods, the use of preformed PVC fitting covers with factory precut insulation insert of the same thickness as adjoining pipe insulation will be accepted. Valves, fittings, etc. shall be insulated by applying the proper factory precut insulation insert to the pipe fitting, valve, etc. The ends of the insulation insert shall be tucked snugly into the throat of the fitting, valve etc. and the edges adjacent to the pipe covering tufted and tucked in, fully insulating the pipe fitting, valve, etc. Vapor barrier mastic compatible with the PVC shall be applied around the edges of the adjoining pipe insulation and on the fitting cover throat overlap seam. The PVC fitting cover shall then be applied and shall be secured with pressure sensitive tape along the circumferential edges. The tape shall extend over the adjacent pipe insulation and have an overlap on itself at least 2" on the downward side.

N. Hot Piping: Install the fiberglass insulation with factory supplied jacket. Butt all joints firmly together and smoothly secure all jacket laps and joints strips with lap adhesive. Valves, fittings, etc. shall be insulated as specified in the Article 3.02.M.

O. For cold piping systems (Refrigeration Piping) Insulation shall be a flexible, closed-cell elastomeric pipe insulation: AP Armaflex, AC Accoflex. Adhesive shall be Armaflex 520, 520 Black or 520 BLV Adhesive.

a. The insulation must conform to ASTM C534 Grade 1, Type I. 1.1.2 Insulation materials shall have a closed cell structure to prevent moisture from wicking which makes it an efficient insulation.
b. Insulation materials shall be manufactured without the use of CFC's, HFC's or HCFC's. It is also formaldehyde free, low VOCs, fiber free, dust free and resists mold and mildew.
c. Insulation materials shall have a flame-spread index of less than 25 and a smoke-developed index of less than 50 as tested in accordance with ASTM E 84. In addition, the products, when tested, shall not melt or drip flaming particles, and the flame shall not be progressive.
d. Insulation materials shall have a maximum thermal conductivity of 0.27 Btu-in./h-ft2 -°F at a 75°F mean temperature as tested in accordance with ASTM C 177 or ASTM C 518. 1.1.6 Insulation materials shall have a maximum water vapor
e. Exterior piping installations shall utilize a protective UV coating (provided by the manufacturer) on the exposed refrigeration piping.

P. Insulation and Protection at Points of Support

1. Install inserts made from rigid calcium silicate pipe insulation at all points of support. Inserts shall be not less than 12" long and of thickness equal to adjoining insulation. A jacket shall be installed over the insert with longitudinal laps and butt strips for circumferential joints smoothly secured with insulation adhesive. Jacket shall provide vapor barrier where required.

2. Install galvanized steel shields between supports and inserts. Shields shall be formed to fit the insulation and shall extend up to the centerline of the pipe and of the length specified for the inserts. Supports shall not pierce the insulation and all vapor barriers shall be unbroken and continuous.

3. In lieu of the foregoing methods, the use of factory fabricated saddle and shields specified in Section 230700 will be accepted.

Q. Outdoor Piping

1. All exposed pipes shall be insulated in accordance with the hot or cold piping Paragraphs as required and shall further be protected with a weatherproof finish. Install aluminum or stainless steel jacket. Joints shall be sealed along the longitudinal seam and circumferential joints with butt strips, minimum 2" wide. Insulation shall be of the waterproof construction.

2. Fitting and valves shall be insulated with segments of the molded insulation and shall be covered using preformed aluminum or stainless steel fittings identical in composition to the jacket. All joints shall overlap 1" and shall be completely weather proof.

3.03 PROTECTION AND REPLACEMENT

A. Replace damaged insulation during construction that cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

B. Protection: Insulation worker shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

3.04 SCHEDULE OF PIPE INSULATION

A. The following piping systems shall be insulated:

1. Cold water, make-up water, supply and return piping for hot, chilled, refrigerant systems. Bonnets of valves in hot and chilled piping shall also be insulated.

2. Condensate drain line from split AC units.

3. Refrigerant piping except liquid refrigerant piping inside the building.

B. Insulation Omitted: Omit insulation on hot piping within radiation enclosures or unit cabinets, flexible connections, expansion joints, liquid refrigerant piping except when installed above roof or exposed to weather.

C. All chilled and hot water piping shall be provided with the following insulation thickness:

1. High Temp Hot Water - Provide 3” thick insulation at conductivity value of 0.22.

2. Primary and Secondary Heating Hot Water - Pipe diameters of < 1 1/2” provide 2.5” thick insulation Pipe diameters ≥ 1 ½” provide 2” thick insulation.

3. Chilled Water - Pipe diameters of < 1 1/2” provide 0.5” thick insulation Pipe diameters ≥ 1 ½” provide 1.0” thick insulation

C. All condensate drain piping located indoors shall be provided with 1” thick insulation.

D. Gas refrigerant piping located indoors and outdoors shall be provided with ½” thick insulation for pipe diameters less than 1” and 1” thick insulation for refrigerant pipe diameters 1” and above.

E. Gas liquid piping located on the exterior of the building shall be provided with ½” thick insulation.

END OF SECTION 23 07 00

SECTION 23 07 01

EQUIPMENT INSULATION (HVAC)

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Provide thermal insulation on the equipment (HVAC) shown on the Drawings, specified herein and needed for a complete and proper installation. Product specific requirements are contained herein; Section 230100, General Provisions for Heating, Ventilating and Air Conditioning Work, shall be referred to for general requirements.

B. All insulation materials shall be free of asbestos.

1.02 RELATED SECTIONS

A. Division 23 Sections

1.03 SUPPLEMENTAL SUBMITTALS

A. Submit schedules showing manufacturer's product number, k-value, thickness and furnished accessories for each equipment requiring insulation.

1.04 SUPPLEMENTAL QUALITY ASSURANCE

A. Installer's Qualifications: Firm with at least three years successful installation experience on projects with mechanical insulations similar to that required for this Project.

B. Code and Standards: Comply with the 2020 NYS ECC and ASHRAE 90.1-2013. All insulation materials shall be labeled in accordance with the identification requirements of Section NYS MC 403 of the 2020 NYSMC (at intervals not greater than 36” with the name of the manufacturer, the thermal resistance *R*-value at the specified installed thickness and the flame spread and smoke-developed indexes of the composite material) and shall have a flame spread index not more than 25 and a smoke developed index not more than 50 (per Sections MC 604.3 and MC 604.5) when tested in accordance with ASTM E84 or UL 723, using the specimen preparation and mounting procedures of ASTM E2231.

1.05 TEMPERATURE REQUIREMENT

A. Apply adhesive, sealers, coating, and other items and accessories at the proper temperatures as recommended by the Manufacturer. If ambient conditions are not acceptable, provide temporary heat as required for proper installation without any delay to the Project completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Approved Manufacturers:

Armacell LLC; AP Armaflex
Thermafiber
CertainTeed Corp.
Knauf Insulation
Johns Manville
Owens-Corning Fiberglas Corp.
Pittsburgh Corning Corp.
Rubatex Corp.
3M VentureClad
Polyguard Products Inc.
Roxul

2.02 MATERIALS

A. Adhesives and Sealants for Insulation: All adhesives and sealants used on interior building insulation shall comply with the South Coast Air Quality Management District (SCAQMD) Rule #1168; VOC limits shall comply with the limits indicated in Table 1 of LEED Version 3.0, Indoor Environmental Quality Section, Credit IEQ 4.1. Those limits correspond to an effective date of the SCAQMD Rule #1168 of July 1, 2005, and Rule Amendment date of January 7, 2005.

B. High density rigid fiber glass board insulation for equipment shall be ASTM C612 Type IA or IB and shall have a thermal conductivity not exceeding 0.26 at 75°F mean temperature. Insulation for field applied rectangular breeching insulation shall be Johns Manville MinWool–1200 Industrial Board Insulation, Roxul ProRox FSL 920NA or equal, 3 pcf, rated to 1200ºF meeting ASTM C612 Type 1A-4A or ASTM C553 Type VII, ASTM E84 (UL 723) max Flame 5, Smoke 0, rated Non-Combustible per ASTM E136, with minimum R value of 4.0 per inch of thickness. Round breeching insulation shall be Johns Manville MinWool-1200 Pipe, Roxul ProRox PS960NA (formerly Techton 1200) or equal, mineral wool rated to 1200ºF, meeting ASTM C447, ASTM C547 and ASTM E84 (UL 723) Flame 5, Smoke 0, rated Non-Combustible per ASTM E136 with thermal conductivity of 0.6 Btu.in/hr.ft^2.ºF.

C. Jackets

1. High Temperature Applications (1200ºF): Provide pre-sized metal jacket except as otherwise shown on the Drawings. Metal jacketing shall be aluminum ASTM B209, Alloys 1100, 30003, 3105 or 5005, Temper H14, 0.016” thick.

   a. Aluminum roll jacketing shall have a smooth outer finish with integral bonded laminated polyethylene film with kraft paper moisture barrier underside.

   b. Aluminum sheet jacketing shall be corrugated $1^{1}/_{4}$" x 1/4" deep with integral bonded laminated polyethylene film with kraft paper moisture barrier underside.

   c. Metal jacketing fastener straps shall be Type 18-8 stainless steel, 0.020" thick, 1/2" wide.

2. Applications Not Exceeding 240ºF: Vapor barrier jacket shall be a laminated five-ply self-adhesive permanent acrylic system; high puncture, tear resistant; product shall be used for outdoor applications; zero permeability; manufactured with mold inhibitors: VentureClad 1577CW, VentureClad 1577CW-E, Alumaguard Lite, Alumaguard “All Weather” LT or equal.

D. Equipment Insulation Compounds: Provide adhesives, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.

E. Equipment Insulation Accessories: Provide staples, wire netting, tape, anchors and stud pins as recommended by insulation manufacturer for applications indicated.

F. Cements

1. Fibrous Glass Thermal Insulating Cement: Asbestos free; ASTM C195

2. Fibrous Glass Hydraulic Setting Thermal Insulating and Finishing Cement per ASTM C449/C449M.

G. Wire and Bands

1. Binding and Lacing Wire: Nickel copper alloy or copper clad steel, gauge as specified

2. Bands: Galvanized steel, 1/2" wide x 0.015” thick, with 0.032” thick galvanized wing seals.

H. Metal Corner Angles: galvanized steel, 2” x 2” 28 gauge

PART 3 - EXECUTION

3.01 COMPLETION OF TESTS

A. Before applying the insulation, all tests specified in Division 23 Sections should have been completed. Do not proceed with work until unsatisfactory conditions have been corrected an final installation approved by the inspectors and/or EOR.

3.02 SUPPLEMENTAL INSTALLATION

A. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gaping joints and excessive voids resulting from poor workmanship.

B. Insulation shall not be applied until the pumps and tanks has been connected, tested, and found to be operating satisfactorily. All surfaces of the pumps and tanks to be insulated shall be clean and dry.

C. Do not insulate handholes, cleanouts, ASME stamp, and manufacturer's nameplate. Provide neatly beveled edge at interruptions of insulation.

D. Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames and accessories.

E. Install equipment high-density Type IA or IB rigid fiberglass block or board. Insulation shall be held in place with No. 16 gauge soft annealed or galvanized steel wire. Joints and voids in the insulation shall be filled with mineral wool cement. Joints and breaks in the vapor barrier for cold equipment shall be sealed by applying vapor barrier coating. Finish shall consist of embedding open weave glass fabric (20 x 20) into a wet coating overlapping the seams at least 2". A finish coat shall then be applied to the entire insulated surface.

3.04 PROTECTION AND REPLACEMENT

A. Replace damaged insulation during construction that cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

B. Protection: Insulation shall be protected during the remainder of the construction period, to avoid damage and deterioration.

3.05 EXISTING INSULATION REPAIR

A. Repair damaged sections of existing mechanical insulation, both previously damaged and damaged during construction. Use insulation of same thickness as existing insulation, install new jacket lapping and sealed over existing.

B. Repair insulation with the same type of materials and thickness in building alteration work where existing equipment insulation is removed and/or damaged due to equipment repair or alteration.

3.06 SCHEDULES FOR EQUIPMENT INSULATION

A. Cold Equipment (Below Ambient Temperature):

1. Chilled water pumps, chilled water tanks (air separators and expansion tanks).

2. Drip pans under chilled equipment.

Insulate each item of equipment specified above with the following types: Type IA or IB fibrous glass fiber insulation: 2" thick for surfaces above 35ºF and 3" thick for surfaces 35ºF and lower.

Upon completion of installation of insulation, penetrations shall be caulked. Two coats of vapor retarder coating or vapor barrier jacket shall be applied over insulation, including removable sections, with a layer of open mesh synthetic fabric embedded between the coats. The total dry thickness of the finish shall be 1/2". Caulking or vapor barrier tape shall be applied to parting line between equipment and removable section insulation.

B. Hot Equipment (Above Ambient Temperature):

1. Hot Water Expansion Tanks.

2. Hot Water Pumps

3. Air Separator Tanks

4. Heat Exchangers (Tube and Shell)

5. Air Separators

Insulate each item of equipment specified above with the following type: Type IA or IB fibrous glass fiber insulation 2" thick

END OF SECTION 23 07 01

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SECTION 23 07 02

DUCTWORK INSULATION

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Provide thermal insulation on the ductwork installed and required on this Project shown on the Drawings, specified herein and needed for a complete and proper installation. Product specific requirements are contained herein; Section 230100, General Provisions for Heating, Ventilating and Air Conditioning Work, shall be referred to for general requirements.

B. All insulation materials shall be free of asbestos.

1.02 RELATED SECTIONS

A. Division 23 Sections

1.03 SUPPLEMENTAL SUBMITTALS

A. Submit schedule showing manufacturer's product number, k-value, thickness and furnished accessories for each duct system requiring insulation.

1.04 SUPPLEMENTAL QUALITY ASSURANCE

A. Installer's Qualifications: Firm with at least three years successful installation experience on projects with mechanical insulations similar to that required for this Project.

B. Flame/Smoke Ratings: Provide mechanical insulation with flame spread index of 25 or less and smoke developed index of 50 or less, as tested by ASTM E84 method or UL 723, using the specimen preparation and mounting procedures of ASTM E223. Insulation shall not flame, glow, smolder or smoke when tested in accordance with ASTM C411 at the temperature to which they are exposed in service or a minimum of 250°F

C. Code and Standards: Comply with 2020New York State Construction Code, 2020 New York State Energy Conservation Code (NYSECC) and ASHRAE 90.1-2013

D. Identification: External duct insulation and factory-insulated flexible duct shall be legibly printed or identified at intervals not greater than 36” with the name of the manufacturer, the thermal resistance *R*-value at the specified installed thickness and the flame spread and smoke-developed indexes of the composite material per Section MC 604.7.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Approved Manufacturers:

Babcock & Wilcox; Insulating Products Div.
Certain Teed Corp.
Knauf Insulation.
Johns Manville
Owens-Corning Fiberglass Corp.
Pittsburgh Corning Corp.
Rubatex Corp.
3M VentureClad
Polyguard Products

2.02 MATERIALS

A. Adhesives and Sealants for Insulation: All adhesives and sealants used on interior building insulation shall comply with the South Coast Air Quality Management District (SCAQMD) Rule #1168; VOC limits shall comply with the limits indicated in Table 1 of LEED Version 3.0, Indoor Environmental Quality Section, Credit IEQ 4.1. Those limits correspond to an effective date of the SCAQMD Rule #1168 of July 1, 2005, and Rule Amendment date of January 7, 2005.

B. Fiberglass Board Type: 3-lb minimum density, thermal conductivity not exceeding 0.23 at 75ºF mean temperature, factory applied facing of aluminum foil reinforced with fiberglass yarn mesh and laminated to 40 lb kraft paper chemically treated to give the permanent flamespread and smoke-developed characteristics required.

C. Fiberglass (Blanket) Flexible Type: 1.5 lb nominal density, thermal conductivity not exceeding 0.29 at 75ºF mean temperature; factory applied foil reinforced kraft facing as specified for the fiberglass board.

D. Calcium or Magnesium Silicate Block: Asbestos free rigid hydrous calcium or magnesium silicate block shall be lightweight with thermal conductivity not exceeding 0.42 at 200°F mean temperature.

E. Calcium-Magnesium-Silicate (CMS) Wool Wrap: CMS wool wrap blanket insulation shall be flexible, high temperature rated, two-hour/zero-clearance and shall be (per Buildings Bulletins 2009-028, 2010-021 and 2015-013) tested and listed to ISO 6944, “Fire-Resistance Test for Ventilation Ducts”, ASTM E814/UL 1479, Fire Test of Through-Penetration Firestop”, and ASTM E84, Standard Test Method for Surface of Building Material”. Fire-rated flexible duct wrap insulation shall consist of foil scrim encapsulated blanket of various thicknesses. The material is directly applied to the duct surface and is used to achieve a fire-resistance rating. Flexible fire-rated duct insulation shall be labeled as per Section §28-113.4. All shipments and deliveries of materials shall be accompanied by a certificate or label certifying that the materials shipped or delivered are equivalent to those tested and approved. Fire-rated flexible duct wrap insulation shall not have a flame spread rating of more than 25 and a smoke developed rating of more than 50 pursuant to ASTM E84.

F. Jackets for Ductwork Insulation: ASTM C921; Type I for ductwork with temperatures below ambient; Type II for ductwork with temperatures above ambient. (Type I-Vapor Barrier, Type II-Water Vapor Permeable).

G. Ductwork Insulation Accessories: Provide staples, bands, wires, tape, anchors, corner angles and all other items and accessories recommended by insulation manufacturer for applications indicated.

H. Ductwork Insulation Compounds: Provide cements, adhesives, coatings, sealers, protective finishes and all other items and compounds recommended by insulation manufacturer for applications indicated.

I. Vapor Barrier Jacket

1. Outdoor applications: Provide jackets made of 0.016" aluminum or stainless steel held with friction type, Z-locks, 12” apart.

PART 3 - EXECUTION

3.01 COMPLETION OF TESTS

A. Before applying the insulation, all tests specified in Division 1 and Division 23 Sections should have been completed. Do not proceed with work until unsatisfactory conditions have been corrected an final installation approved by the inspectors and/or EOR.

3.02 SUPPLEMENTAL INSTALLATION

A. Materials used as internal insulation and exposed to the air stream in ducts shall be shown to be durable when tested in accordance with UL 181. Exposed internal insulation that is not impermeable to water shall not be used to line ducts or plenums from the exit of a cooling coil to the downstream end of the drain pan (Reference Section MC 604.13). Omit insulation on ductwork where shown on the Drawings.

B. Duct coverings shall not penetrate a wall or floor required to have a fire resistance rating or required to be fireblocked per Section MC 604.6. Linings shall be interrupted at the area of operation of a fire damper and at a minimum of 6” upstream of and 6” downstream of electric resistance and fuel burning heaters in a duct system. Metal nosings or sleeves shall be installed over exposed duct liner edges that face opposite the direction of airflow per Section MC 604.8.

C. Fiberglass board shall be used to insulate ductwork that is exposed in fan or equipment rooms.

D. Flexible type duct insulation shall be used to insulate ductwork that is installed in concealed spaces (hung ceilings, furred spaces, pipe and duct spaces, crawl spaces and tunnels).

E. Installation of Board Type Insulation

1. Insulation shall be applied with edges tightly butted. It shall be impaled on pins welded to the duct and secured with speed clips impaled over the pins. Pins shall be cut off close to speed clips. On horizontal ducts, pins shall be spaced not less than one per square foot for the bottom surface, and not less than one per two square feet on the sides and top surface. On vertical ducts, the pins shall be spaced not less than one clip per two square feet of duct surface. For faced insulation cold air ductwork, point all joints and cracks with vapor barrier coating, and seal all joints and speed clips with a 3" wide strip of foil-reinforced-kraft facing adhered with vapor barrier/insulation adhesive. The use of pressure sensitive tape of the same facing material also is acceptable for this purpose. For cold air ductwork, the laminated self-adhesive vapor barrier jacket will be accepted.

2. Where the welded pin method cannot be used because of space or size restriction, the use of stick clips will be approved and the insulation shall be additionally secured to the duct with insulation adhesive. The adhesive shall cover the entire surface of the sheet metal when applied to underside of horizontal duct, but may be applied in strips for application to top and sides with a minimum of 50% coverage. Insulation shall be additionally secured with No. 16 gage soft annealed or galvanized steel wire on not more than 12" centers. Continuous metal, corner angles shall be used to protect edges of the insulation.

G. Installation of Flexible Type Insulation: Flexible type insulation shall be cut slightly longer than the perimeter of the duct to insure full thickness at corners. Insulation shall be applied with edges tightly butted, and seams stapled approximately 6" on centers with outward clinching staples. Insulation shall be additionally secured with No. 16 gage soft annealed or galvanized steel wire on not more than 12-inch centers. When the width of a horizontal duct is 24" or more, the insulation shall also be fastened with welded pins or stick clips spaced on 18-inch centers on the bottom surface of the duct. All joints and clips shall be taped and sealed with 3" wide strips of foil-reinforced-kraft facing applied with insulation adhesive. The use of pressure sensitive tape of the same facing material also is acceptable for this purpose. For cold air ductwork, vapor barrier coating or laminated self-adhesive vapor barrier jacket will be accepted.

H. No Used

I. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

J. Maintain integrity of vapor-barrier on ductwork insulation, and protect it to prevent puncture and other damage.

K. Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise indicated such as rated penetrations.

L. Not Used

Per Buildings Bulletins 2009-028 and 2015-013: Ducts lined on the inside with combustible material shall not utilize fire-rated flexible duct wrap insulation (unless manufacturer submits documentation that their duct wrap is provided in accordance with the national standards that are recognized by OTCR).

3.03 EXISTING INSULATION REPAIR

A. Repair damaged or removed sections of existing duct insulation, both previously damaged/removed and damaged/removed during construction. Use insulation of same type and thickness as existing insulation, install new jacket lapping and sealed over existing.

3.04 PROTECTION AND REPLACEMENT

A. Replace damaged insulation that cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

B. Protection: Insulation Worker shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

3.05 SCHEDULES OF DUCTWORK INSULATION

A. Insulation Omitted - Do not insulate the following:

1. Access door, test hole fittings, damper quadrants, except as otherwise specified. The adjoining insulation shall be neatly finished around such devices.

2. Exhaust ductwork need not be thermally insulated, except the portion of the duct between motorized spill damper and spill louver.

3. Omit insulation on horizontal return air ductwork installed inside ceilings. Return air risers inside air shafts shall be insulated.

4. Omit insulation on ductwork where shown on the Drawings.

B. Exposed Ducts/Plenums in Boiler Room, Custodian's Workshop, Equipment and Mechanical Rooms, Receiving Room, and any room without a drop ceiling:

1. Insulate

a. All outside air intake plenums not pre-insulated at the factory

b. Outdoor air intake ducts in their entirety.

c. Exhaust duct from motorized spill damper to spill louver.

d. Supply and return ducts

e. Heating plenums not pre-insulated at the factory

2. Insulate the above with rigid fiberglass board, minimum R12.

C. Supply and Return Air Duct Work:

1. Insulate concealed supply ductwork in its entirety from the fans (or blower unit) to room terminal inlets and outlets.

2. Insulate return air ductwork located inside air shafts.

3. Insulate the above with flexible fiberglass minimum R12.

END OF SECTION 23 07 02

SECTION 23 09 00

INSTRUMENTATION AND CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. This Section is coordinated with and complementary to the General Conditions and Supplementary General Conditions of the Work, wherever applicable to HVAC Work.

B. Sections 23 00 00 & 26 00 00- Special Requirements for Mechanical and Electrical Work shall apply.

1.2 DESCRIPTION OF WORK

A. The Temperature Control Contractor shall provide the control system as indicated in the plans and specifications for a complete and proper installation. This Section includes control equipment for HVAC systems and components, including control components for terminal heating units that are not supplied with factory-wired controls.

B. The control system shall be complete in all respects and shall be installed by competent Temperature Control Contractors meeting the criteria of the DASNY design standards and specifications and the pre-qualified criteria of the Authority. See Article 1.5 for submittal requirements.

The TCC shall employ qualified personnel with the proper license, training and certification required for the work specified.

C. The control system specified shall be solely a digital stand-alone system that can**,** without additional equipment, perform the entire automatic temperature control and energy management functions required for the Project.

The DDC System will consist of stand-alone controllers with flat, open architecture that utilizes BACnet protocol, when the digital controllers are BACnet controllers. When the digital controllers are BAcnet controllers, provide BACnet compliant products that have the potential to communicate on multiple channels to meet the functional requirements of this specification and the dedicated product functional specifications and profiles specified. All terminal unit controllers shall be native BACnet.

D. Provide controllers, instrumentation, control devices, control panels, controller programming and controller programming software, setpoints, alarms, controller input/output and power wiring, database generation, and associated control devices.

E. TCC shall furnish to the mechanical contractor and to the unit equipment manufacturers, control end devices i.e. damper actuators, automatic control valves, valve operators, temperature and pressure sensors, etc. in accordance with the requirements of Section 23 00 00.

F. Furnish and field install terminal BACnet controllers for the air handling units. TCC to coordinate with MC and GC. Air handling units may be provided with non-BACnet controls provided a gateway to BACnet is available.

G. Provide one (1) portable laptop that is the Human Machine Interface (HMI) for the system that permits the operator to facilitate terminal controller management (and central unit controller management in

addition to the central unit controller HMI), commissioning, diagnostics and general operator interface with the installed control system. The POT shall connect directly to all controllers.

H. The Division 26 00 00 Electrical Contractor shall provide 110 VAC power for use by the Temperature Control Contractor.

I. The DDC system shall consist of stand-alone Application Specific Controllers (ASC). Standalone controllers shall have their own integral time clocks and schedulers. The DDC system shall also include sensors, automatic valves with actuators, damper actuators and other such devices; operating software, approved submittal, operation and maintenance manuals, start-test-check documentation, as-built documents, operator training, installation labor, warranty and all other necessary material and labor to provide a complete and workable system.

J. Provide wire, raceway systems, back-boxes, 24VAC and/or 24VDC power supplies and all final connections to devices shown on drawings.

K. All the necessary fittings to install wells, meters, and other accessory equipment and all wiring shall be included. All the equipment shall be furnished by the control manufacturer and installed under the control manufacturer's supervision.

L. Provide and install devices/controllers, relays, switches, thermostats, sensors, damper operators, conduit, wiring, tubing and panels to provide a complete temperature regulation and control operation system. All wiring shall be run according to building lines (no angles) and concealed where possible. All wiring shall be installed in a workmanlike manner as outlined in the New York State Building and Electrical Codes. Installation shall comply with all local control system electrical codes.

M. Checkout of the system shall be by the Temperature Control Contractor.

N. Core drill for wall and floor openings and seal up around the conduits and wiring with smoke-tight sealant. (Refer to Fire Stopping and Joint Sealers Sections of the complete project specification).

O. Wiring connections in panels shall be properly labeled in a manner easily identifiable using the control drawings.

P. Schedule

All work shall be in conjunction with applicable Authority construction schedules and the Temperature Control Contractor shall coordinate his work with other trades.

Q. Manpower and support

1. The Temperature Control Contractor shall provide adequate, qualified manpower for the purpose of providing a complete control installation within the construction time schedule established by the Authority.

2. The Temperature Control Contractor shall provide adequate, qualified manpower for all peripheral functions including equipment start-up, test and balance, commissioning, and owner training; unless otherwise specified.

3. TCC shall provide coordination of work with the General Contractor (GC), Mechanical Contractor (MC) and other trades.

4. Contract Coordination:

a. TCC shall submit requests for product substitutions to the AEOR. All substitutions shall be approved prior to installation. Costs associated with changes as a result of utilizing a substitute product shall be borne by the Temperature Controls Contractor.

b. When BACnet controls are provided, TCC shall submit product Interface files and wiring interconnection diagrams to the AEOR for approval and to the Authority.

c. TCC shall provide individual start-up and commissioning of each stand-alone controller installed.

d. TCC shall replace defective products found to be defective during the commissioning of the DDC system.

e. Control step-down transformers (110VAC/24VAC) shall be provided by the TCC. If any 110VAC power is required for control devices, flow meters, etc., a licensed electrician retained by the TCC shall install it. The TCC shall provide overall coordination and shall have overall responsibility for the installation.

1.3 OTHER SERVICES

The work scope shall also include the furnishing of services of various engineering disciplines both in the field and in home office in order to complete the work in a satisfactory and professional manner. The Temperature Control Contractor is responsible for providing these engineering services.

The Authority's Project Officer will monitor the Temperature Control Contractor's schedule and progress during the engineering, procurement, installation, testing and commissioning stages of the job. Scheduling, monitoring, and expediting of all furnished material and equipment under the scope of this Specification is the Temperature Control Contractor's responsibility. The Temperature Control Contractor shall provide sufficient manpower to perform these tasks to the satisfaction of the Authority's Project Officer.

The services to be provided by the Temperature Control Contractor under this Specification shall include:

A. Provide technical direction of the installation as specified herein.

B. Provide field calibration, testing and commissioning of equipment as specified herein.

C. Incorporate Uninterruptible Power Supply surge transient protection in the installation of the system to protect electrical components in all operators' workstations.

D. Provide submittals, software, data entry facilities (Portable Operator's Terminal, POT), programming, startup, test and validation, training of the Building Engineering Department Representative on maintenance and operation, as built documentation and system warranty.

E. Provide special tools, testing equipment as required for operation, installation, and maintenance of the equipment specified herein.

F. Provide documentation and complete Operating and Maintenance Manuals.

REFERENCES

A. References and industry standards listed in this Section are applicable to the Work. Unless more restrictive criteria or differing requirements are explicitly stated in the Specifications, or mandated by governing codes or regulations, the recommendations, suggestions, and requirements described in the referenced standards shall be deemed mandatory and applicable to the Work.

B. Perform the work in accordance with the requirements of Section 23 05 00 Basic HVAC Requirements and with the provisions of all applicable codes and laws.

C. The installation and equipment is to conform to all applicable building and electrical code articles and reference standards cited therein.

D. Abbreviations

AGC	Application Generic Controller
ASC	Application Specific Controller
BAC	BACnet Control
CAC	Custom Application Controller
COS	Change-of-State
CPU	Central Processing Unit

DDC	Direct Digital Controller
DPR	Damper
DPU	Digital Point Unit
DRF	Device Resource File
DWG(S)	Drawing(s)
EP	Electric-Pneumatic
FPB	Fan Powered VAV Box
FPM	Feet per minute
FACP	Fire Alarm Control Panel
FCC	Fire Command Center
FMS	Fire Management System
GPM	Gallons per minute
HVAC	Heating, Ventilating and Air Conditioning
ITC	Intermediate Telecommunications Closet
I/O	Input/Output
NFPA	National Fire Protection Association
OI	Operator interface
OS	Operating System
OWS	Operating Work Station
PE	Pneumatic-electric
PID	Proportional Integral Derivative
PRV	Pressure Reducing Valve
PSI(g)(a)	Pounds per square inch (gauge)(absolute)
RAM	Random Access Memory
TCS	Temperature Control System
TCC	Temperature Control Contractor
UL	Underwriters' Laboratory
VAV	Variable Air Volume
VCS	Voice Communication System
inch WC	Inches of Water Column

RELATED SECTIONS

A. Division 26 Sections

B. Division 27 Sections

SUBMITTALS

The TCC shall transmit all submittals directly to the AEOR who shall do a review to assess compliance to the contract drawings and specifications. The Submittals shall be in Electronic PDF format with all schematic diagrams, product data sheets and supporting documentation provided for the complete system. Within thirty (30) days after date of execution of General Contractor/Sub-Contractor agreement, the Temperature Control Contractor shall submit for acceptance (by the Authority's AEOR a list of all material and equipment manufacturers whose products are proposed, as well as names of all subcontractors whom the Temperature Control Contractor proposes to employ.

The Temperature Control Contractor shall submit within six weeks of contract award the following according to conditions of Contract and as applicable:

A. General and Product Data

Manufacturer's catalog data describing each item of control equipment or component provided and installed

for the project, including dimensions, finishes, general construction, specific modifications, component connections, description of anchorage methods, and installation procedures. Provide installation details and specific instructions for valves, air damper actuators, flow sensors, temperature wells and pressure taps. Descriptive data and sequence of operations for operating user and application software, including complete operator's manual and programmer's manual. Portable Operator's Terminal technical data.

Point-to-point and basic function commissioning forms to be used on site for the start, test and check of control components and systems. Instrumentation to be used for testing and calibrating during point-to-point and basic function testing. Functional performance test documentation and procedures to be used in commissioning control sequences.

Product data on all components used to meet the requirements of the specifications such as enclosures, Interface File documentation, configuration parameter options, mounting details, power supplies, etc.

Proposed changes and substitutions of systems, apparatus, equipment, and manufacturer's proposal materials to be submitted for approval.

Hardware demonstration and Acceptance Testing Procedure as required for the Temperature Control Contractor's request for substantial completion.

Manufacturers' startup instructions, including specific requirements.

B. Shop Drawings: Provide 3/8" scale AutoCAD shop-drawings of the following:

1. Hardware, Power, and Cabling:
   Arrangement and location of hardware devices/controllers including the field installed devices.
   Power connection requirements including terminal designations.

c. Interconnect cabling between hardware.

2. Specific locations for 110 VAC power required for control panels, control transformers, and 110 VAC field control devices, if any, such as flow meters, etc.

3. Electrical low voltage power wiring schematic indicating voltage drop calculations, wire size, power consumption, maximum full load circuit amperage.

4. Control Diagram: Submit functional temperature control diagrams for each mechanical system served by the HVAC Control System. Use at least one individual sheet for each major HVAC system.
   a. HVAC system flow diagram with sensing, control and interlock devices.
   b. Internal control panel layouts, control panel cover layouts, electrical connections inside control panels.
   c. Ladder-type wiring diagrams showing interlock, monitoring and control wiring to and from equipment, including control systems equipment.
   d. Provide a summary point's list and software points as per contract documents including Control Diagrams and the control sequence of operations included on the contract drawings.
   e. Indicate and Tag each input/output served by each device.

5. Flow-chart control sequences.

C. Schedules

List component sizes, mounting orientations, capacities and locations.

1. Valve

2. Damper actuator

3. Pressure tap

4. Temperature well

5. Temperature and humidity

6. Thermostats

D. Qualifications

1. TCC Technical experience sheet

2. TCC Qualification

3. Technician BACnet training certificate

E. Field Test Reports: Submit all the field test reports and results; inspection checklists and compliance forms as specified in this Section.

F. Training: Submit training program, course outline and operating manual for approval.

G. Close-out Items

1. The Temperature Control Contractor shall provide the complete documentation of the system and shall provide a licensed copy of each software tool that the Temperature Control Contractor is required to use to create the system and to complete his work.

2. As-Built Drawings
   a. Upon completion of the work, the Temperature Control Contractor shall provide as a deliverable submittal a complete set of Autocad format as-built drawings and application software on electronic media. This submittal shall in turn be delivered to the Department of Education.
   b. As-built drawings shall contain all changes, modifications, alterations, etc. which have occurred on the project since the approval of the control system submittal. Additionally, field information shall also be included on these as-built drawings indicating wire-numbers, wire-pull information, actual terminal block numbers, routing information, and shall indicate where spare wires have been installed. The intent is to provide and document to the Owner all field-related installation knowledge.
   c. Any errors in as-built conditions discovered shall be submitted to the AEOR, who will return them to the TCC for correction. The TCC is responsible for accurate as-built documentation of his work.
   d. The Temperature Control Contractor shall provide AutoCAD generated floor plans indicating exact installed location of the following equipment and/or devices:
      Sensors located in Finished Areas.
      Units installed by Division 23 and 26 trade contractors.
      Other DDC related components, sensors and actuators.
3. Operation and Maintenance Manuals, including:
   Shop drawings and product data in Project Record format.
   One laminated, non-fading, appropriate size, not to exceed 11 inch by 17 inch copy of each system type. See Section 3 on O&M Manuals and List of Required Submittals for additional information.
4. Guarantees specified in the “GUARANTEE” Article
5. Special warranty conditions, special servicing conditions, and expanded warranty or service contract

proposals.
6. List of recommended spare parts and calibration tools for owner's maintenance staff.
7. Portable Operator's Terminal (POT)

Keys for locking access doors of control valves and thermostat guards.

SUBSITUTIONS

Wherever the words for "review" or "acceptance" are used in regard to manufactured specialties, or wherever it is desired to substitute a different make or type of apparatus for that specified, submit all information pertinent to the adequacy and adaptability of the proposed apparatus to the Authority's AEOR and secure their approval before apparatus is ordered.
Wherever system performance such as material quantities, operating pressure or the like are specified, or a definite make and size of apparatus is specified, for which such quantities are readily determinable, the make and size of the apparatus proposed must conform substantially to the quantities specified or implied. Critical dimensions relating to the installation of apparatus and coordination with the rest of the system shall be considered and adhered to whenever possible. Substitution of equipment or apparatus shall include all necessary revisions and their costs required to complete the installation.
Approval of request for substitutions may be given only after receipt of complete and satisfactory performance data covering the complete range of operating conditions in tabular and graphical form. Furnish complete and satisfactory information relative to equipment performance, features and accessories, etc.
Additional construction and design costs incurred as a result of any accepted substitution shall be borne by the Temperature Control Contractor.
Proposed changes and substitutions of systems, apparatus, equipment and manufacturers will be considered, subject to the approval of the Authority's AEOR. The proposal shall include the following information:
A description of the difference between the existing contract requirements and that proposed the comparative features of each, and the effect of the change on the end result performance. Include the impact of changes on other Contractors and/or subcontractors and acknowledge the inclusion of implementation costs.
Schematic drawings and details to supplement the descriptions.
A list of the contract requirements that must be revised if the change is accepted, including any suggested specification revisions.
Complete list of materials and equipment proposed for use in the change.
Include a description and estimate of costs the Authority may incur in implementing the change, such as test, evaluation, operating and support costs.
A projection of any effects the proposed change would have on collateral costs to the Authority.
A statement of the time by which a contract modification accepting the change must be issued, noting any effect on the contract completion time or the delivery schedule.
A statement indicating the reduction to the contract price if the Authority's AEOR accept the change. The Temperature Control Contractor shall be responsible for appropriate modification of any subcontractor's scope of work.

QUALITY ASSURANCE

Submissions by Wholesalers, Contractors, Distributors, Independent Temperature Contractors, or any firm that is determined, by the discretion of the Authority not to be significantly in the business of manufacturing and installing automatic temperature control systems, shall not be acceptable. All TCC bidders must have successfully completed the DASNY Pre-Qualification process.

The system shall be designed by competent, factory-trained application and software engineers as well as installed by competent, factory-trained technicians, regularly employed by the Temperature Control Contractor. The Temperature Control Contractor shall have full responsibility for proper design, installation, commissioning, and warranty of each component in the entire system. The Authority's AEOR shall approve

all commissioning procedures submitted and to be employed by the Temperature Control Contractor. The Temperature Control Contractor shall provide all required commissioning programming to allow for simple and effective demonstration of the Sequence of Operations by being able to generate or simulate all parameters necessary to demonstrate the functionality. This should include the ability to step though the typical heating and cooling modes of operation and all transitions between modes. The Temperature Control Contractor shall be responsible for using competent and skilled mechanics and electricians in the installation of the system. The Temperature Control Contractor shall provide company support for the overall installation and performance of the system.

The Temperature Control Contractor shall have an in-place, fully-staffed, factory-supported facility within fifty (50) miles of the jobsite. Support facility shall have a spare parts inventory and all necessary test and diagnostic equipment required to install, commission, and service the specified system. As evidence and assurance of Authority's long-term availability to product support, system service and parts, the installing Temperature Control Contractor must have been in business for a minimum of five (5) years. The Temperature Control Contractor shall employ technicians to provide instruction, routine maintenance, and emergency service within twenty-four (24) hours upon written receipt of request.
As a further assurance of the timely and cost effective availability of additional or replacement parts, application specific controllers, sensors, actuators, relays, valves and miscellaneous repairs, said parts shall be available either directly from the manufacturer or a local factory-authorized parts wholesalers and/or distributors.

The Temperature Control System shall be furnished and installed by a BACnet HVAC Controls contractor having manufacturer support. In addition, the Temperature Controls Contractor supervisor must show evidence as being trained on the control manufacturer's BACnet toolset (as listed in Article 2.1). Even though a network is not being installed for the project, native BACnet controls are required for the terminal systems. The TCCs shall have completed the above courses so the network-less system is installed such that a future network will be able to be installed in a possible future network installation.
For digital controls that are native BACnet, comply with BACnet Testing Laboratories Guidelines for all products when the controller(s) can meet the specified Sequence of Operations as shown on the contract drawings. BACnet Gateways shall be provided in the event BACnet products are not available for the control application. Utilize published functional profiles for all product configuration parameters.

For digital controls that are native BACnet, utilize Standard BACnet Object types.
Experience Record Provide a list of no less than three similar projects that have control systems as specified. These projects must be on-line and functional such that the Authority's Representative can observe a BACnet direct digital control system in full operation. At least two (2) projects shall be using BACnetTM control products and approved toolsets. Submit resumes with the proposal indicating the BACnet System integrator training and prior Instrument and Controls experience, including project references, references contact and phone numbers. If a previously submitted and accepted key-person is no longer available to the project, they shall be replaced by a person with equal training and prior experience within a thirty (30) day time period. This period is to begin when the key-person becomes unavailable to the project. The resumes of these replaced personnel shall be submitted for review during this thirty (30) day time period.

Codes and Standards

The latest edition and addenda of the publications listed in Section 23 00 00 and the following publications in effect on the date of Contract award are part of this specification and, where referred to by title or basic designation only, are applicable to the extent indicated by the specific reference:

Department of Labor State of New York (NYDL)
Rule 23 – Industrial Code, Protection in Construction, Demolition, and Excavation operations
Building Code of the State of New York

National Fire Protection Code (NFPA) 241 Safeguarding Construction, Alteration, and Demolition Operations
Electrical Standards: Provide electrical components of control systems that have been UL listed and labeled.
NEMA Compliance: Comply with NEMA standards pertaining to components and devices of the control systems.
NFPA Compliance: Comply with NFPA 90A: Standard for the Installation of Air Conditioning and Ventilating Systems where applicable to controls and control sequences.
National Electrical Code (NEC) and applicable local electrical code.
American National Standards Institute (ANSI).
American Society of Mechanical Engineers (ASME).
American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
Institute of Electrical and Electronic Engineers (IEEE).
USA Standard Code for Information Interchange (ASCII.
Electronics Industries Association (EIA).
Instrument Society of America (ISA).
Federal Communication Commission (FCC) Regulation Part 15.

SERVICE LIFE GUIDELINES

The Temperature Control Contractor shall provide guidelines for service life and replacement requirements for control devices and controllers. Where installation procedures, or any parts thereof, are required to be in accord with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Authority's AEOR before installation. Installation of the item will not be allowed to continue until the recommendations are received. Should any error or inconsistency appear in the drawings, specification, or Contract, or should the Temperature Control Contractor be uncertain as to the work, the Temperature Control Contractor shall, before proceeding with the work, inform the Authority's AEOR of same in writing and then proceed with work as directed by the Authority's AEOR in writing.

SPECIAL REQUIREMENTS

Qualification of Proposed Temperature Control Contractor (TCC)

1. The Temperature Control Contractor shall be Pre-Qualified and listed in the Authority's "BACnet Temperature Controls" approved Vendor List.
2. The purpose of this information is to assure that as applicable, all phases of engineering, design, and equipment furnished, and construction will be performed by parties demonstrating sufficient prior experience in their areas of responsibilities.

Documentation of Temperature Control Contractor's Qualification
Submit resumes indicating passing certificates for the control manufacturer's BACnet courses. Such proof must include summary of coursework and indicate both written and laboratory requirements of alternate training.

Submit a list of similar projects, which have BACnet digital control systems installed. These projects must be on-line and functional such that the Authority's Representative can observe the DDC Control System in full operation. Submit an organizational diagram indicating the key technical staff proposed for the project including, Project Manager, Superintendent, Electrical Foreman, etc.

Materials and Equipment

All materials and equipment shall be new, bear manufacturer's name, and conform to the grade quality and standards specified herein. Type capacity and application shall be capable of satisfactory operation for the purpose intended. All materials and equipment shall be adequately covered and protected against dirt, water,

chemical or mechanical damage and theft. At completion, all work equipment and materials shall be cleaned, and damage repaired by Temperature Control Contractor.

Coordination with Existing Utilities

1. The Temperature Control Contractor must coordinate with the Authority for scheduling of the work. Any interruptions or shutdowns of existing service must be held to minimum. Shutdowns shall be coordinated by the Authority.
2. Whenever it becomes necessary to interrupt existing services in use in the area, such as HVAC or electric service, the Temperature Control Contractor shall continue the work on a twenty four-hour basis (at no additional cost to the Authority) until the work is completed and the system restored. Before beginning such work, the Temperature Control Contractor shall apply in writing, to receive approval from the Authority to establish a time when the interruption of service will cause minimum of interference with the activities in the area.

DELIVERY, STORAGE, AND HANDLING

Provide factory-shipping cartons for each piece of equipment and control device. Keep equipment and control devices in carton while shipping, in storage and while handling to prevent equipment damage and to eliminate dirt and moisture. Store equipment and materials inside and protect from weather.
Products shall be provided with complete documentation. This shall include diagrams of all BACnet objects (when BACnet controllers are provided) supported by the product as well as relevant technical specifications. Undocumented BACnet products must be tagged and accepted by Authority's AEOR prior to installation. Do not install undocumented products without such acceptance.
All products and materials shall be new, clean, and free of defects, damage, and corrosion.
Ship and store products and materials in a manner that will protect them from damage, weather, and entry of debris. Do not install damaged items but take immediate steps to obtain replacement or repair.

PERFORMANCE

A. The Temperature Control Contractor shall provide the HVAC Sequence of Operations as per shown on the contract drawings.

SERVICING OF SYSTEMS

Provide the following services to maintain the control system during the guarantee period.
Services shall be rendered within twenty-four (24) hours of notification of problem.

Servicing to include following:

a. Emergency service.
b. Replacing defective parts and components as required.
c. Maintaining of system programming.
d. Incorporating improved system reliability as it becomes available.
e. COOPERATION AND COORDINATION
f. Apparatus and equipment specified under other Sections and Divisions:
g. Examine Plans, Specifications and coordinate with work of other Divisions. Examine control systems supplied with factory package equipment.
h. Provide interfacing items as required.
i. Examine and compare the DDC System Specifications and Drawings with the Specifications and Drawings of the other trades and report any discrepancies between them to Authority. Obtain the Authority's written instructions for changes necessary in the DDC System work. Install and coordinate the DDC System work in cooperation with the other trades installing interrelated work.

All changes required in the work of the Temperature Control Contractor, caused by noncompliance with the specifications, shall be made at Temperature Control Contractor's expense.

C. Carefully check space requirements with other trades to ensure that all material can be installed in the allotted spaces, including above finished suspended ceilings.

D. Wherever work interconnects with work of other trades and vendors, coordinate with other trades to ensure that all trades have the information necessary so that they may properly install all the necessary connections and equipment.

E. Coordinate, protect and schedule work with other trades in accordance with the construction sequence.

F. Install the DDC System work to permit removal (without damage to other parts) of other parts requiring periodic replacement or maintenance.

G. Make certain that all materials selected directly or selected by suppliers conform to the requirements of the Specifications. Transmittal of such Specification information to persons manufacturing and supplying materials to the project, and rigid adherence thereto, is the Temperature Control Contractor's responsibility.

GUARANTEE

A. Provide the following:
   1. Two-year workmanship and material guarantee for all work of this Section starting from completion of the commissioning of the system.

B. Within the guarantee period, upon notice by the Authority, any defects in the work provided under this section due to methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced by the Contractor at no expense to the Authority. The TCC shall minimize impacts on facility operations when performing scheduled repairs and non-scheduled work, which is to be done during non-school hours.

C. All corrective software modifications made during guarantee service periods shall be updated on all user documentation and provided on a USB flash drive at no cost to the Authority.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

Compatible BACnet controllers shall be provided. Controllers shall be native BACnet or shall be available with a gateway to BACnet. Providing a BACnet gateway is beyond the scope of work for the project. Control systems conforming to the requirements of the Drawings, Specification and job conditions shall be manufactured by one of the following manufacturers, meeting the requirements of BACnet system architecture (latest revision providing the required control sequence functionality) and the approval of the Authority's AEOR.

Acceptable Manufacturers
Schneider Electric BACnet Toolset
Siemens BACnet Toolset
Johnson Controls Inc. BACnet Tool Set
Honeywell Spyder Tool Set
Distech (BACnet Toolset)
Alerton BACnet Tool Set
Automated Logic BACnet Tool Set

Note: The TCC shall provide a license copy (latest version) of the control system toolset to the Department of Education for use and storage.

Acceptable Products
Digital controllers shall be BACnet compatible. The Temperature Control Contractor shall furnish and install BACnet products manufactured by preferably by one manufacturer. Materials and equipment shall be

catalogued products and shall be manufacturer's latest standard design that complies with the specification requirements.

2.2 GENERAL REQUIREMENTS

General BACnet Control Product and System Requirements
Custom Application Controllers (CAC), Application Specific Controller (ASC) and Application Generic Controllers (AGC) shall contain their control programs in programmable non-volatile memory and their operating systems in firmware. Each controller shall have the intelligence to perform control strategies without communication to other control units.
Controllers and Intelligent Devices shall be able to have their sequence of operation program edited and/or modified. The hard wired inputs and outputs shall be able to be configured and reconfigured to permit the controller to accept field modifications and/or different operating strategies. Each controller shall complete an entire internal scan in less than one second. Each internal scan shall consist of updating inputs, making necessary mathematical calculations, and sequencing appropriate outputs for local control.
As a minimum, provide a separate CAC for each major piece of HVAC equipment. Points used for control loop reset such as outside air or space temperature shall be hardwired to each controller as shown on the Drawings. All controllers shall have their own integral real time clock and scheduler and shall be seasonally adjustable to manually select the heating mode or the cooling mode.
When Application Specific Controller (ASC), Application Generic Controllers (AGC) and/or Custom Application Controllers (CAC) are applied, provide the following minimum spare points for each controller:
(2) Universal Inputs (AI/BI), or
(1) Analog Input and (1) Binary Input.
(1) Analog Output.
(1) Binary Output.

Operating system software shall reside in Read Only Memory (ROM). Application software shall reside in EEPROM or flash memory. The real-time operating system provided in ROM memory shall require no operator interaction to initiate operations.

The operating system shall include:

Operations and management of control.
Error detection and recovery from arithmetic and logical faults.
Watchdog timers and sleep/wake-up logic.
System self-testing.

G. Product application software shall be developed in Flow Chart Format or Visual Control and capable of being downloaded.

2.3 HVAC CONTROLS - EXECUTION

This article defines the Basic Materials and Methods used in the installation of BACnet compliant control products to provide the functions necessary for control of the mechanical systems identified on this project. The control system shall be designed such that each mechanical system will be able to operate under stand-alone control.
The documentation contained in this section and other contract documents pertaining to HVAC Controls is schematic in nature. The Temperature Control Contractor shall provide hardware and software necessary to implement the functions shown or as implied in the contract documents.

2.4 DDC HARDWARE REQUIREMENTS

2.4.1 PORTABLE OPERATORS' TERMINAL (POT)

To Interface with Terminal BACnet controllers (that must be native BACnet) and central unit controllers that may be native BACnet)
The Temperature Control Contractor shall provide one Portable Operator Terminal (POT) interface device, for use by the Temperature Control Contractor for system commissioning during project implementation.
The Portable Operator Terminal shall be turned over to the Complex Engineering Department (Building Engineer) once the system has been commissioned and approved by the Authority's Representative(s).

The Portable Operator Terminal shall incorporate the following items as a minimum requirement.

MS/TP BACnet Network Interface and/or BACnet IP.
10/100 Ethernet Network Interface card (for possible future network)
Operating System Software
User Display Screen (15" XGA Active matrix)
4 GB RAM, minimum
Intel I5 processor (or faster)
One 160 GB hard drive
Two USB Ports
Touch pad mouse
Two-year, next-business-day, on-site maintenance service contract with Accidental Damage coverage.
Acceptable Manufacturers: Dell, HP, Lenovo
The Portable Operator Terminal Interface Device shall be capable of supporting all BACNET network transceiver types (MS/TP, Ethernet/TCP/IP, etc.) and provide for the ability to serve multiple control channels (to support a possible future network).
The Portable Operator's Terminal shall have a factory-installed Operating System to include Microsoft Windows Professional, or latest Compatible Version.
The Portable Operator's Terminal shall have factory-installed client software to include Microsoft Office Professional (including Internet Explorer, latest version).
The Portable Operator's Terminal shall be capable of Client Server operations to MS/TP, or Ethernet TCP/IP BACnet channels (to support a possible future network).
The Portable Operator's Terminal shall be equipped with manufacturer specific program and configuration applications or "plug-ins" for connecting directly to and communicating with all devices/controllers.

2.4.2 APPLICATION SPECIFIC CONTROLLER (ASC)

General Requirements
Application Specific Controllers shall be equipped with DDC a microprocessor controller (BACnet compatible), a minimum of 64K programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
Operating system software, operating sequence software and application programs shall be stored in programmable, non-volatile memory.
The ASC unit shall be equipped with a dedicated software clock battery. The battery shall be capable of maintaining time-of- day, day-of-week, date, month, and year, independent of system power for a 72 hour period. ASC (such as Space Comfort Controllers) shall have their own scheduler.
ASC Interface Software
General: ASC shall be configured, not programmed, via PC based interface software. This software shall be a program applet, which runs within the software package provided by the TCC in the POT. Intimate knowledge of operation of ASC shall not be required for configuration.
ASC shall provide a selection of control applications performable through configuration of the device. Download of new application should not be required for one of these applications.

ASC Device Software
General: An ASC shall operate in standalone mode, as needed for specified control applications. Software shall include a complete operating system (O.S.), communications handler, point processing, standard control algorithms, and specific control sequences.
Operating System software shall reside in programmable flash memory, operate in real-time, provide prioritized task scheduling, control time programs, monitor and manage future network communications, and scan inputs and outputs. Operating System shall also contain built in diagnostics.

2.4.3 APPLICATION GENERIC CONTROLLER (AGC)

General Requirements
Application Generic Controllers shall be equipped with a DDC microprocessor controller (BACnet compatible), a minimum of 1MB programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, network transceivers.
Operating system software, operating sequence software and application programs, as approved by the AEOR, shall be stored in programmable, non-volatile memory.
The AGC unit shall be equipped with a dedicated software clock battery. The battery shall be capable of maintaining time-of-day, day-of-week, date, month, and year, independent of system power for a 72 hour period. Each AGC shall be equipped with its own scheduler.
AGC Interface Software
General: AGC shall be configured, not programmed, via PC based interface software (BACnet Service Tool Set). This software shall be a program that is compatible with MicroSoft Windows and a BACnet network management tool which will be used if a future network is installed. Intimate knowledge of operation of AGC shall not be required for configuration.
AGC shall provide a selection of control function blocks that can be configured. Download of new applications from network management tool shall be possible, but not required.

2.4.4 CUSTOM APPLICATION CONTROLLER (CAC)

General Requirements
Custom Application Controllers shall be equipped with a DDC microprocessor controller, a minimum of 1MB programmable non-volatile (flash) memory for general data processing, power supply, input/output modules, termination blocks, and network transceivers.
Operating system software, custom operating sequence software (manufacturer's tool sets as defined in Article 2.1) and application programs shall be stored in programmable, non-volatile memory.
The CAC unit shall be equipped with a dedicated software clock battery. The battery shall be capable of maintaining time of day, day of week, date, month, and year, independent of system power for a 72 hour period. CAC Freely Programmable Controllers shall have their own scheduler.
CAC Software
General: All CACs shall operate in standalone mode. Software shall include a complete operating system (O.S.), communications handler, point processing, standard control algorithms, and specific control sequences.
O.S. software shall reside in programmable flash memory, operate in real-time, provide prioritized task scheduling, control time programs, monitor and manage CAC to input/output communications, and scan inputs and outputs. O.S. shall also contain built in diagnostics.
Input/Output Point Processing Software shall include:
Continuous update of input and output values and conditions. All continuous points are to be updated at a minimum of one-second intervals.
Reasonability checks on all analog inputs against the previously read value and discards those values falling outside pre-programmed reasonability limits.
Assignment of proper engineering units and status condition identifiers to all analog and digital input and outputs.

Analog input alarm comparison with the ability to assign two individual sets of high and low limits (warning and actual alarm) to an input or to assign a set of floating limits (alarm follows a reset schedule or control point) to the input. Each alarm shall be assigned a unique differential to prevent a point from oscillating into and out of alarm. Alarm comparisons shall be made each scan cycle.
De-bounce of digital inputs to prevent nuisance alarms. De-bounce timing shall be adjustable from two seconds to two minutes in one-second increments.
Alarm Lockouts
Alarm lockout software shall be provided to prevent nuisance alarms. On initial start-up of air handler and other mechanical equipment a "timed lockout" period shall be assigned to analog points to allow them to reach a stable condition before activating alarm comparison logic. Lockout period is to be programmable on a per point basis from 0 to 90 minutes in one-minute increments.
Custom DDC Control Loops
Custom DDC programs are to be provided to meet the control strategies as called for in the sequence of operation sections of these specifications. Each DDC Controller shall have residential in its memory and available to the programs a full library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences:
All DDC setpoints, gains and time constants associated with DDC programs shall be available to the operator for display and modification via the portable operator's terminal and POT workstation.
DDC control programs shall include an assignment of initialization values to all outputs to assure that controlled devices/controllers assume a fail-safe position on initial system start-up.

2.4.5 HARD-WIRED DEVICES

Outside air temperature or humidity sensors, occupancy buttons or CO2 sensors are to be hard wired. All primary control loop sensors such as duct pressure transmitters, space temperature or humidity sensors are to be hard-wired to the controller’s I/O points.

2.5 ELECTRONIC INPUT/OUTPUT DEVICES

Temperature and Humidity Sensors and Transmitters
General Sensor & Transmitter Requirements
Provide sensors and transmitters required as outlined in the input/output summary and sequence of operation and as required achieving the specified accuracy as specified herein.
Temperature transmitters shall be equipped with individual zero and span adjustments. The zero and span adjustments shall be non-interactive to permit calibration without iterative operations. Provide a loop test signal to aid in sensor calibration.
Temperature transmitters shall be sized and constructed to be compatible with the medium to be monitored.
Transmitters shall be equipped with a linearization circuit to compensate for non-linearity of the sensor and bridge and provide a true linear output signal.
Temperature sensors shall be of the resistance type and shall be either three-wire 100 ohm platinum RTD, or two-wire 1000 ohm platinum RTD.
Thermistors may be acceptable provided that the temperature vs. resistance curves are contained either in the controller’s software or firmware and that its performance is as specified herein elsewhere. Submit proof of the software mathematical equation or the firmware conversion charts together with the temperature/resistance charts from the manufacturer of the sensor. Thermistors shall be of the Thermistor (NTC) Type with a minimum of 100 ohm/°F resistance change versus temperature to insure good resolution and accuracy. Thermistors shall be certified to be stable ±0.24°F. over five years and ±0.36°F. accurate and free from drift for five years.
The following accuracies are required and include errors associated with the sensor, lead wire and A to D conversion.

Point Type	Accuracy
Outside Air	0.5°F

Room Temperature	1.00°F
Duct Temperature	0.5°F

Thermowells
Thermo-wells are required for all temperature sensors in fluids transported within piping such as, but not limited to, water and steam.
Thermo-wells shall be supplied as a complete assembly including the sensor, separable well, wellhead and Greenfield fitting.
Thermowells shall be pressure rated and constructed in accordance with the system working pressure
Thermowells and sensors shall be mounted in a threadolet or 1/2" NPT saddle and allow easy access to the sensor for repair or replacement.
Thermowells shall be filled with heat-conductive compound which is specifically manufactured for the application. The compound shall be suitable for the temperature range being sensed.
Thermowells shall be constructed of the following materials:

1) Chilled and Hot Water; brass.
2) Steam; 316 stainless steel.

Duct-Mounted Sensors
Duct-mounted sensors shall mount in a handibox through a hole in the duct and be positioned so as to be easily accessible for repair or replacement. A neoprene grommet (Sealtite fitting and mounting plate) shall be used on the sensor assembly to prevent air leaks.
Duct sensors shall be insertion type allowable for discharge air temperature measurement.

Acceptable Manufacturers and Model Numbers

1) Bapi BA/series
2) Veris Industries TD series
3) Greystone TE200 Series
4) GE Sontay Model LN-TT-522-FTT
5) Dwyer Series TE or approved equal

4. Averaging Duct Type Sensors
Provide for ductwork measurement to account for air temperature measurement of mixed air temperatures and discharge air temperatures for ductwork greater than 36 inches and where air temperature stratification exists. Temperature Control Contractor shall utilize averaging duct temperature sensors for these applications. The use of duct insertion type sensors is prohibited for these applications.

The Temperature Control Contractor shall utilize an averaging sensor with multiple sensing points using either of two designs.

a) The averaging sensor shall be a flexible copper tube containing multiple thermistor sensors wired in a manner to average their resistance and therefore their temperatures. The sensing element shall be fastened in such a manner that the element not come into direct contact with any sharp, or abrasive metal. Use of averaging straps intended for this purpose is required.
b) The averaging sensor shall be a galvanized steel tube with holes extending across the duct or plenum to be sampled. A bleed hole outside the duct or plenum causes air to enter the sample tube and exit at the bleed hole, thus bathing the sensor in average air. The averaging sensor shall be installed complete with end-cap, compression fittings, gaskets, mounting flange and required accessories.

Provide capillary supports at connection point to the duct to support the sensing element and to prevent abrasion damage to the sensor.

Acceptable Manufacturers and Model Numbers
Bapi BA/series

Veris TA series
Greystone TE200 series
Dwyer Series AVG
or approved equal

5. Duct Relative Humidity & Temperature Sensors

Specifications – Humidity Element

Operating range	0 to 100% RH
Accuracy at 68oF (20oC)	±2% RH, 20-95% RH including hysteresis, linearity, and repeatability
Operating temperature	32 to 122oF (-6 to 50oC)
Temperature effect	Less than 0.06% per degree F
Sensing element	Capacitive
Output signal-RH only units	4-20 mA, 0-10 VDC, 0-100% linear, proportional (Provide interface to BACnet controller)
Output signal-RH/T units	0-10 VDC, 0-100% linear, proportional
Polarity protection	Yes

Specifications – Temperature Element

Operating temperature	20 to 122oF (-6 to 50oC)
RTD calibration point	32oF (0oC)
Accuracy	±1oF (±0.55oC)
Sensing element	1,000 Ohm RTD
Output signal	0-10 VDC 0-100% linear, proportional
Calibration adjustments	None required

General Specifications

Installation	18 AWG cable length shared in conduit with other sensor wiring 750-ft (229m) max
Connections	Screw terminals
Dimensions	Duct Probe: 1/2" O.D. x 7"L (123.7 mm x 177.8 mm) Duct Housing: 4" L x 4½" W x 2½" D (102 mm x 115 mm x 64 mm)
Voltage requirement	13.5 to 35 VDC or 24 VAC

Duct RH/T Sensor 5% (0-10 VDC)
Siemens Model Number 538-896 or Kele GEH series
or Bapi Model Number BA/xx-H210 or Dwyer Series RH or approved equal

6. Room Relative Humidity Sensors

Specifications – Humidity Element

Operating Range	0-100% RH
Accuracy at 77°F	±2% at 20-95 RH%
(Element only)	including hysteresis, linearity, and repeatability
Sensing Element	Capacitive
Operating Temperature	32-122°F
Temperature Effect	Less than 0.06%/°F
Output Signal (RH/T Unit)	4-20 ma DC 0-100% linear, proportional

Acceptable Manufacturers and Model Nos.

a. Greystone Model Number RH200A
b. Veris Model Number HD2XVSTC2
c. Kele GEH series
d. Dwyer Series RH

7. Outside Air Temperature and Humidity Sensors

Outside air temperature and humidity sensors shall be designed to withstand the environmental conditions to which they will be exposed. All outdoor applications shall utilize NEMA 4x enclosures. The sensing element shall be 100-ohm platinum RTB with minimum 2% accuracy over the operable range of not less than -30°F to 130°F service. They shall also be provided with a solar shield.

The outside air temperature sensor shall be furnished with a sun-shield to reduce the heating effects of reflected sunlight from adjacent surfaces. This shield surrounding the sensor element shall also protect the sensors against wind velocity effects.

Outside sensors shall be mounted on a north-facing surface, out of direct sunlight, and away from other heat surfaces. Install the outside air humidity and CO2 sensors adjacent to the outside air temperature sensor. Outside Temperature and humidity sensors shall comply with the section 2.8.and shall be rated for ambient temperatures.

e. Acceptable Manufacturers and Model Numbers
Bapi BA/xx-H210-0-EU
Veris HO series
Greystone TE200 serie
s

8. Room Sensors (Temperature Only)

Room temperature sensors are to be provided with a cover to prevent accidental damage. Refer to Part 3 Execution.
Terminal unit temperature sensors shall all be of the thermistor (NTC) type with a 100-ohm/oF resistance change versus temperature change to insure good resolution and accuracy.
Sensor shall be supplied with a vertical base for mounting on a standard single gang junction box supplied by the Temperature Control Contractor.
Temperature sensor cover plate shall be vandal proof, flush mounted stainless steel with hex head hardware.

9. 7-day Programmable BACnet Thermostats

7-day programmable thermostats shall be used in all building areas7-day programmable thermostats shall have a local display and allow for 7-day schedule configuration with local buttons.
7-day programmable thermostat shall provide a 7-day programming clock, up to three heat or cool outputs, fan output, allow remote temperature sensor input and provide a display in degree F.
Thermostat shall be powered from 24 VAC.
Thermostat shall incorporate BACnet Standard Profiles.
Acceptable manufacturers include Distech EC-Stat, Schneider Electric, Honeywell, Johnson Controls, and Viconics.
Differential Pressure Transmitters and Accessories
General Air and Water Pressure Transmitter Requirements:
Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage and to hold calibrated accuracy when subject to a momentary 40% over-range input.
Pressure transmitters shall provide the option to transmit a 0 to 5VDC, 0 to 10VDC, or 4 to 20 mA output signal.
Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device and shall be supplied with shutoff and bleed valves in the high and low sensing pick-up lines (two way or 3-way valve manifolds as applicable).
Provide the transmitter with a NEMA rating suitable for its installed location. Locate transmitters in

accessible local control panels wherever possible.
Duct sensing pressure applications where the velocity exceeds 1500 fpm shall utilize static pressure traverse probes.
Low Air Pressure Applications (0 to 0.5-inch WC)
The pressure transmitter shall be capable of transmitting a linear electronic signal proportional to the differential of the room and reference static pressure input signals with the following minimum performance specifications.
Span: Not greater than two times the design differential pressure.
2) Accuracy: Plus or minus 0.5% of F.S.
3) Dead Band: Less than 0.3% of output.
4) Repeatability: Within 0.2% of output.
5) Linearity: Plus or minus 0.2% of span.
6) Response: Less than one second for full span input.
7) Temperature Stability: Output < 0.01%/°F shift.
8) Pressure transmitters shall transmit a 0 to 5VDC, 0 to 10VDC, or 4 to 20 mA output signals.
The transmitter shall utilize variable capacitance sensor technology and be immune to shock and vibration.
Acceptable Manufacturers
Air Monitor
Foxboro
Rosemont
Setra (F5 Model)
Brandt
Ashcroft.XLDP
Medium to High Air Pressure Applications (0.5" to 10.0-inch WC)
The pressure transmitter shall be similar to the Low Air Pressure Transmitter except the performance specifications are not as severe. Provide differential pressure transmitters which meet the following performance requirements:
Zero & span: (% F.S./Deg. F): 0.041% including linearity, hysteresis and repeatability
2) Accuracy: 1% F.S. (best straight line)
3) Static Pressure Effect: 0.5% F.S. (to 100 psig)
4) Thermal Effects: <±.03% F.S./°F over 40°F to 100°F (calibrated at 70°F.)
5) Pressure transmitters shall transmit a 0 to 5VDC, 0 to 10VDC, or 4 to 20 mA output signal.
Acceptable manufacturers:
Mamac
Setra
Modus
Dwyer
Low Differential, Water Pressure Applications (0” to 20-inch WC)
The differential pressure transmitter shall be of industrial quality and transmit a linear output in response to variation of flow meter differential pressure or water pressure sensing points.
The differential pressure transmitter shall have non-interactive zero and span adjustments adjustable from the outside cover and meet the following performance specifications.
0.01 – 20-inch WC input differential pressure range
2) Maintain accuracy up to 20:1 turndown ratio
3) Reference Accuracy: ± 0.2 % of full span
4) Pressure transmitters shall transmit a 0-5 VDC, 0-10 VDC, or 4-20 mA output signal.
c. Acceptable Manufacturers:
Tobar - Model 75DPl
Foxboro - Model 823 DP
Omega - Model PX750 - 15OD1
Bailey
Rosemount 2051 Transmitter

Medium to High Differential Water Pressure Applications (21-inch WC to 100 psi)
The differential pressure transmitter shall meet the low pressure transmitter specifications except the following:
Differential pressure range from 21-inch WC to 100 psi.
Reference Accuracy: ± l% of full span (includes non-linearity, hysteresis, and repeatability)
Pressure transmitters shall transmit a 0-5VDC, 0-10VDC, or 4-20 mA output signal.
Acceptable Manufacturers: Dwyer, Mercoid, Schaevitz, Setra and Mamac.
Bypass Valve Assembly: Mount stand-alone pressure transmitters in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with hi and low connections piped and valved. Air bleed units, bypass valves and compression fittings shall be provided.
Electronic Valve Actuators
General Requirements (where required)
Electronic actuators shall be electric, direct-coupled type capable of being mounted over the shaft of the valve. They shall be UL-listed and the manufacturer shall provide a 2-year unconditional warranty from the date of Substantial Completion. Power consumption shall not exceed 8 watts or 15 VA of transformer sizing capacity per high torque actuator nor 2 watts or 4 VA for VAV actuators. Sound level shall not exceed 45 dB for high torque or 35 dB for VAV actuators.
Electronic overload protection shall protect actuator motor from damage. If damper jams, actuator shall not burnout. Internal end switch type actuators are not acceptable. Actuators may be mechanically and electrically paralleled on the same shaft to multiply the available torque. A reversing switch shall be provided to change action from direct to reverse in relation to control signal as operation requires.
Electronic valve modulating actuators shall be driven by a 0-10VDc or 4-20 mA signal.
Control Damper Actuators
Outside Air (OA) and Exhaust Air (EXH) actuators shall be modulating, spring-return, normally-closed for fail-safe operation.
The control circuit shall be fully modulating using 0-10VDC or 4-20mA signals. Accuracy and repeatability shall be within ±1/21 of control signal. A 0-10VDC or 4-20mA signal shall be produced by the actuator which is directly proportional to the shaft clamp position which can be used to control actuators which are paralleled off a master motor or to provide a feedback signal to the automation system indicating damper position. Accuracy shall be within ±2.5%.
Face and bypass dampers and other control dampers shall be modulated using the same control circuit detailed above but shall not be spring-return.
Acceptable manufacturers: Belimo, Honeywell, Johnson Controls, Siemens, Schneider Electric, Dodge or Delta.
Miscellaneous Damper Actuators
OA combustion and ventilation air intake and EXH damper actuators shall be two-position, spring-return, normally-closed if any water piping, coils or other equipment in the space which the damper serves needs to be protected from freezing. Otherwise drive open, drive closed type 2 position may be used. The minimum torque for any actuator shall be 50 inch-lbs.
Acceptable manufacturers: Belimo, Honeywell, Johnson Controls, Siemens, Schneider Electric, Dodge or Delta.
Inlet Vanes Actuators
DDC control systems shall utilize variable frequency drives (VFD) for fan modulation. For pneumatic projects or special requirements with the Authority’s permission, inlet vane actuators shall provide at least 150% of the minimum torque specified by the manufacturer as necessary to operate vanes properly. Either direct-coupled or gear-train with linkages are acceptable as required. The fan speed control loop shall be tuned to avoid hunting and to maintain stable control.
Combination Smoke and Fire Damper Actuators
Actuators shall be factory mounted and connected to the damper section and shall conform to UL-555S specifications and Section 15915. They shall be rated for 350°F. Coordinate with Fire Alarm contractor for actuator voltage and normally open/normally closed orientation.
Valve Actuators

Control Valves Actuators (3 inch and smaller)
Actuators shall have a gear release button on all non-spring return models to allow manual setting. Pipes shall be fully insulated and heat shields shall be installed if necessary.
The control circuit shall be fully modulating using 0-10 volt or 4-20 mA signals. Accuracy and repeatability shall be within 1/21 of control signal. A 0-10VDC or 4-20mA feedback signal shall be produced by the actuator which is directly proportional to the shaft clamp position which can be used to control actuators which are paralleled off a master motor or to provide a feedback signal to the automation system indicating valve position.
Valve body and actuators shall be shipped fully assembled and tested at the valve factory prior to shipment.
Acceptable Manufacturers:
Dodge
Delta
Belimo
Schneider Electric
Siemens
Honeywell
Control Valve Actuators (4 inch and larger).
The valve actuator shall consist of a permanent split capacitor, reversible type electric motor which drives a compound epicycle gear. Unit shall be mounting directly to the valves without brackets and adapters, or readily adapted to suit all other type quarter-turn valves.
The actuator shall have an integral terminal strip, which, through conduit entries, will ensure simple wiring to power supplies.
The actuator shall be constructed to withstand high shock and vibrations without operations failure. One copy of the wiring diagram shall be provided with the actuator.
The actuator shall have a self-locking gear train which is permanently lubricated at the factory. The gearing shall be run on ball and needle bearings. Actuators with 600 in/lbs. or more output torque shall have two adjustable factory calibrated mechanical torque limit switches of the single-pole, double-throw type. The motor shall be fitted with thermal overload protection. Motor rotor shaft shall run in ball bearings at each end of motor.
The environmental temperature range of the actuator shall be -30°C to +60°C (-20°F to +140°F).
The actuator shall be capable of operating 100% of the time at an ambient temperature of 40°C.
The actuator shall have an integral self-locking gear train. Motor brakes shall not be required to maintain desired valve position. Levers or latches shall not be required to engage or disengage the manual override.
Mechanical travel stops, adjustable to 15° in each direction of 90° rotation shall be standard, as well as two adjustable travel limit switches with electrically isolated contacts. Additional adjustable switches shall be available as option.

E. Carbon Dioxide Sensor

Sensor used for demand controlled ventilation for Public Assembly spaces subject to intermittent occupancy shall be Kele Vaisala GMW21 or GMD20 Series, or Honeywell. The sensor shall be a silicon-based NDIR sensor conforming to the following specifications:

Range	0-2000 ppm CO2
Accuracy @ 77°F	2% of reading (±30 ppm)
Linearity	±1% FS
Stability	<5% FS for 5 years
Response Time	1 min
Output Signal	0-20mA or 4-20mA, and 0-10 VDC
External Load (Current)	500 Ohms max
External Load (Voltage)	1k Ohm min
Power Supply	Nominal 24 VAC/VDC
Power Consumption	2.5W
Warm-up Time	15 min.

Operating Temperature	23 to 113°F
Operating Humidity	0-85% non-condensing
Airflow Range (GMD20)	0-2000 fpm
Relay Output	1000 ppm (adjustable)

2.6 SWITCHES

Differential Pressure Switches
All pressure sensing elements shall be corrosion resistant. Pressure sensing elements shall be bourdon tubes, bellows, or diaphragm type. Units shall have tamper-proof adjustable range and differential pressure settings. Unit shall be provided with indicating 4" Magnehelic gauge (or approved equal). Two pressure sensor snap-acting, dry-contact micro-switches shall be provided that shall be rated up to 10A @ 120VAC, 60 Hz. Sensor assembly shall operate automatically with manual reset, one required for each circuit. Complete sensor assembly shall be protected against vibration at all critical movement pivots, slides, etc. Unit shall have 2% full-scale accuracy at 70°F and shall be UL approved.
Unit shall be rated for 10" Hg to 25 psig total overpressure on either side of the diaphragm.
Ambient temperature: 20°F to 120°F.
Acceptable Manufacturers: Dwyer Photohelic A3000 Series or approved equal
Electric Low-Limit Thermostat (Freezestat)
Duct-type, fixed-differential, temperature range of 5.0°F. Sensing element shall be a 20-foot long capillary tube responding to the lowest temperature sensed along any segment (typically between two and twelve inches) of bulb length. Hardwired contacts shall be provided. One NC-SPST rated for 16A @ 120VAC, 9.2A @ 208VAC; 8A @ 240VAC, and one NO-SPST rated for 6A @ 120VAC, 3.3A @ 208VAC; 3A @ 240VAC. Unit shall be manually reset. Provide one low limit thermostat for each twenty (20) square-feet or fraction thereof of coil surface area.
The NC-SPST contact shall be hardwired into the supply fan motor control circuit, and shall not be wired in the auto-leg of the HOA switch. The NO-SPST contact shall be wired into the DDC controller as a digital input.
Provide hardwired interlocked manual-reset type thermostat set at 35°F on each air handling unit, with an adjustable (0 to 120 second) delay before the fan shuts down.
Provide an override of this safety-shutdown for air handling units requiring smoke-purge initiation from the Fire Alarm System. Coordinate override with Fire Alarm Contractor.
Water Flow Switches
UL-listed, suitable for all service application conditions. Body minimum working pressure rating shall equal or exceed service pressure. Switch electrical rating shall be 230 volts AC 3.7 ampere, 115 volts AC 7.4 ampere, and 125 VAC 115-230 VAC Pilot duty. Unit shall have two SPDT switches. Actuating flow rated shall be field adjustable for the specified and indicated service. Switch location shall preclude exposure to turbulent or pulsating flow conditions. Flow switch shall not cause pressure drop exceeding 2 psi at maximum system flow rate. Manufacturer: McDonnell-Miller FS7-4.
Strap-On Aquastat
UL-listed, provided with a suitable removable spring-clip for attaching aquastat to pipe and a snap-action SPDT switch. Switch adjustable setpoint shall be as indicated. Electrical rating shall be 5 Amps, 120 VAC.
Duct Smoke Detector
See Electrical section 16720 for specifications. See Specification 15501 for Schedule of Responsibilities.

2.7 FLOW, PRESSURE, TEMPERATURE AND ELECTRICAL MEASURING APPARATUS

Temperature Controls Contractor (TCC) shall coordinate with the General Contractor (GC), Mechanical Contractor (MC) and equipment manufacturers for the furnishing and installing of the sensors. Any sensors not factory provided shall be field provided by the TCC.

A. Low Velocity and High Turndown Air Flow Applications

1. Low velocity and high turndown air flow units shall be used for:

Outdoor air applications due to dust and low velocities

Applications where turndowns of greater than 3 to 1 are required or measurement of duct average velocities ranging less than 750 fpm are required
Turbulent locations within placement recommendations of the manufacturer, where 5 upstream and 1 downstream duct diameters from turbulence causing devices are not available due to physical duct constraints
Provide airflow/temperature measurement devices where indicated on the plans. Fan inlet measurement devices shall not be substituted for duct or plenum measurement devices.
Each measurement device shall consist of one or more sensor probe assemblies and a single microprocessor-based transmitter. Each sensor probe assembly will contain one or more independently wired sensor housings. Multiple independent sensors shall produce measurements equally weighted and averaged by the transmitter prior to output. Pitot tubes and arrays are not acceptable. Vortex shedding airflow meters are not acceptable.
All Airflow/Temperature Measurement Sensor Probe Assemblies
a. Each sensor housing shall utilize two hermetically sealed, bead-in-glass type thermistor probes used to determine airflow rate and ambient temperature. Devices that use "chip" type thermistors are unacceptable. Devices that do not have two thermistors in each independent sensor-housing are not acceptable.
b. Each independent sensor-housing shall be calibrated at a minimum of sixteen (16) airflow rates and have an accuracy of ±2% of reading over the entire operating airflow range. Each sensor assembly shall be factory calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).
c. Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.
d. The operating temperature range for the sensor probe assembly shall be -20°F to 160°F. The operating humidity range for the sensor probe assembly shall be 0-99% RH (non-condensing).
e. Each temperature sensor shall be calibrated at a minimum of 3 temperatures and have an accuracy of ±0.15°F over the entire operating temperature range. Each temperature sensor shall be factory calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST).
f. Each sensor probe assembly shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to a remotely mounted transmitter. All interconnecting pins shall be gold plated.
g. Each sensor assembly shall not require matching to the transmitter in the field.
h. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter at a given measurement location.
5. Duct and Plenum Airflow and Temperature Sensor Probe Assemblies
a. The number of sensor housings provided for each location shall be as follows:

a.	Area (sq.ft.)	Sensors
	<=1	2
	>1 to <4	4
	4 to <8	6
	8 to <12	8
	12 to <16	12
	>16	16

b. Probe assembly mounting brackets shall be constructed of stainless steel. Probe assemblies shall be mounted using one of the following options:
1. Insertion mounted (through the side or top of the duct)
2. Internally mounted (inside the duct or plenum)
3. Standoff mounted (inside the plenum, immediately upstream of an intake damper or downstream of a filter or coil bank.)
c. The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

6. Airflow with Integral Temperature Transmitters

a. The transmitters shall have an LCD display capable of displaying airflow and temperature. Airflow shall be field configurable to be displayed as a velocity or a volumetric rate.

b. The transmitter shall be capable of displaying the individual airflow and temperature readings of each sensor on the LCD display.

c. The transmitter shall operate on 24 VAC or 24 VDC. The transmitter shall not require an isolated power source.

d. The operating temperature range for the transmitter shall be -20°F to 120°F. The transmitter shall be protected from weather and water.

e. The transmitter shall be capable of communicating with the host controls using one of the following interface options:

1) Linear analog output signal: Field selectable, fuse protected and isolated, 0-10 VDC and 4-20mA (4-wire)

The airflow/temperature measuring device shall be UL listed as an entire assembly.

The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the TCC shop drawings.

A written report shall be submitted to the Authority's AEOR if any measurement locations do not meet the manufacturer's placement requirements.

Acceptable Manufacturers (or approved equal):

Ebtron Series GP1 Duct and Plenum Probe

Dwyer PFS Series Smart Air Velocity Transmitter

Pitot type airflow measuring stations

General- Pitot type airflow measuring stations shall only be acceptable in locations not excluded in the description in above Article. Airflows average greater than those described in above section provide conditions that would be acceptable for alternates described in this section, providing they can meet the accuracy criteria as described below.

Traverse probes shall be a dual-manifold, cylindrical-type constructed of 3003 extruded aluminum with an anodized finish to eliminate surface pitting and unnecessary air friction. The multiple total pressure manifolds shall have sensors located along the stagnation plane of the approaching airflow and without the physical presence of forward projecting sensors into the air stream. The static pressure manifold shall incorporate dual offset static tips on opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as ±20o in the approaching air stream.

The airflow traverse probe shall not induce a measurable pressure drop, nor shall the sound level within the duct be amplified by its singular or multiple presences in the air stream. Each airflow measuring probe shall contain multiple total and static pressure ports placed at equal distances along the probe length. The number of sensors on each probe and the quantity of probes utilized at each installation shall comply with the ASHRAE Standards for duct traversing.

Traverse probes shall provide test documentation demonstrating error no greater than ±2.5% of the measured airflow range down to 750 FPM. Below 750 FPM Pitot type air flow stations are not acceptable (see section 2.7.A above)

Each air flow measuring device shall be provided with a matched 0.25 %F.S. accurate transmitter.

Transmitters shall be manufactured by the same manufacturer as the Pitot. Transmitters shall not be more than 35% over the full span requirement of the maximum design CFM and shall guarantee total system accuracy (including airflow sensor and transmitter of 5% of reading). Systems that cannot meet this accuracy requirement shall be provided with dual transmitters.

Each flow measuring station shall be complete with its own dedicated microprocessor with a 4-line, 80-character, alpha/numeric display and full function keypad. The panel shall be fully programmable and display calculated CFM directly on a LED monitor on the panel face.

Provide 24 VAC power to each flow measuring station.

Acceptable Manufacturers:

Air Monitor

Brandt

Air Sentinel
Ebtron
Static Pressure Traverse Probe
Provide multipoint traverse probes in the duct at each point where static pressure sensing is required.
Each duct static traverse probe shall contain multiple static pressure sensors located along the exterior surface of the cylindrical probe. Pressure sensing points shall not protrude beyond the surface of the probe.
The duct static traverse probe shall be of stainless steel construction and (except for 3/4" diameter probes with lengths of 24" or less) be complete with threaded end support rod, sealing washer and nut, and mounting plate with gasket and static pressure signal fitting. The static traverse probe shall be capable of producing a steady, non-pulsating signal of standard static pressure without need for correction factors, with an instrument accuracy of 2%.
Acceptable Manufacturers: Mamac, STAT-Probe/l, Brandt; B-SSK 8000
Venturi Flow Meter (GPM)
Pressure drop on venturi type flow meters shall not exceed 0.25-inch WC. Each venturi low and high pressure taps shall be equipped with nipples, valves and quick disconnects.
Equip each venturi with a metal identification tag indicating the size, location, GPM and meter reading for the GPM specified.
Provide (1) 6" dial differential pressure meter of the proper range to determine piping system flow rate.
Venturi meters shall utilize flanged or screwed connections for removal purposes and shall be rated for the system operating pressures.
The venturi flow meter shall be factory calibrated to provide a minimum of flow accuracy between actual and factory flow calibration data. Flow meter shall output a 0-10 VDC or 4-20 mA signal to the DDC controller.
Acceptable Manufacturers: Barco, Gerand, Preso and Aeroquip
Current Transformers
The current transformers shall be designed to be installed or removed without dismantling the primary bus or cables. The transformer shall be of a split core design.
The core and windings shall be completely encased in a UL approved thermoplastic rated 94VA. No metal parts shall be exposed other than the terminals.
The current transformers shall meet the following specifications:
Frequency Limits: 50 to 400 Hz.
Insulation: 0.6 KV Class, 10 KV BIL.
Accuracy: ±1% at 5.0 to 25.0 VA accuracy class with U.P.F. burden.
Provide a disconnect switch for each current transformer. Acceptable models include Kele #U3889 Switch Block with #209PF Cover.
Acceptable Manufacturers: Ohio Semitronics, Technologies, Inc., Triad Technologies, Kele, EMON.
Current Sensing Switches
Current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. Current sensing switches shall consist of a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip into range.
Acceptable Manufacturers: Ohio Semitronics, Technologies, Inc., Triad Technologies, Kele, RIB, Veris Industries or EMON

2.8 CONTROL VALVES AND DAMPERS

General Control Valve Requirements
All automatic control valves shall be linear, fully proportioning, with modulating ball, plug or V-port inner guides unless otherwise specified. The valves shall be quiet in operation and fail safe in either normally open or normally closed position in the event of control air failure or loss of electronic low voltage power.
All valves shall be capable of operating in sequence when required by the sequence of operation. All control valves shall be sized by the Temperature Control Contractor, and shall be guaranteed to meet the heating and cooling loads as specified. Valve authority (i.e. ratio of open valve pressure drop to closed valve pressure

drop) shall be greater-than or equal-to 0.5 for throttling valve applications. The pressure drop through the control valve when it is fully open shall be at least 50% of the pressure drop from the supply to the return line. All control valves shall be suitable for the pressure conditions, and shall close against the differential pressures involved. Valve body pressure rating and connection type (screwed or flanged) shall conform to ANSI pressure classifications appropriate for the system working pressures.

Steam Control Valves
Steam control valves shall be ball valve type with equal percentage flow characteristics. Preheat valves and direct radiation valves shall be normally open type. Reheat and water heater valves shall be normally closed type.
The valve internal surfaces shall be composition type for steam pressure up to 35 psig, and shall be of 316 stainless steel for steam pressures above 35 psig or where subject to superheat after pressure reducing valves.
Whenever the steam flow rate is such as to require a single valve larger than 2", there shall be installed two valves in parallel (which shall operate sequentially), one of which shall not be in excess of 2" in size.
Valves shall be sized for full pressure drop when the inlet pressure is 10 psig or below. When the inlet pressure is above 10 psig the valves shall be sized for a pressure drop equal to 45% of absolute inlet pressure (psia).

Ball type control valves shall be rated for steam service and equipped with 316 stainless steel trim, Teflon seals and adjustable packing gland nuts.

Hot and Cold Water Control Valves
Hot and cold water globe type control valves shall be single-seated type, with equal percentage flow characteristics. The valve discs shall be composition type and shall be sized using ISA methods.
Pressure drop through the valves shall not exceed 5 psig unless otherwise indicated.
Ball valves shall be equipped with 316 stainless steel trim, Teflon seals and adjustable packing gland nuts.
Provide a handle for manual operation during start-up and maintenance.

Two-Position Control Valves
For open/closed and/or three-way diverting applications, butterfly valves are acceptable and shall be heavy-duty pattern with a body rating comparable to the pipe rating.
Provide each butterfly valve with a replaceable lining suitable for temperature and service requirements.
Equip each with a butterfly valve with disc and stainless steel stem.
Valves used for shut-off or isolation purposes shall be bubble-tight.
Automatic Control Dampers (When Not Furnished As Part Of A Packaged Equipment Factory Assembly, i.e. field furnished by TCC, installed by mechanical contractor)
Automatic dampers shall be multiple blades and sized for the application by the Temperature Control Contractor and/or as indicated on the Drawings.

Submit a schedule of damper sizes to the Authority's AEOR within thirty (30) days after being awarded the contract.

Dampers used for throttling airflow shall be of the opposed blade type arranged for normally open or normally closed operation as required. The damper is to be sized so that when wide open the pressure drop is enough of its close-off pressure drop to shift the characteristic curve to near linear. Multi-section dampers must be provided with sufficient interconnecting hardware or jackshaft to provide unison operation of all blades in the entire assembly. Damper frames and blades shall be constructed of either minimum 16-gage galvanized steel or 14-gage aluminum and arranged to facilitate field assembly of several individual sections into a large damper area and allow secure fastening of damper frame to the surrounding ductwork, collar or fan housing. Maximum blade length in any section shall be 48". Additional stiffening or bracing shall be provided for any section exceeding 48" in height.
Damper blades shall not exceed eight (8) inches in width. All blades except for fume hood exhaust systems

shall be galvanized sheet steel. Blades shall be suitable for high velocity performance.
All damper bearings to be made of nylon. Bushings that turn in the bearing are to be oil impregnated sintered metal. Dampers shall be tight closing, low leakage type with synthetic elastomer seals on the blade edges and on the top, bottom and sides of the frame. Dampers shall not leak in excess of 8 cfm per square foot when closing against 4-inch WC static pressure.
Leakage and flow characteristics charts shall be submitted to the Authority's AEOR.

2.9 ELECTRICAL CONTROL POWER AND LOW VOLTAGE WIRING

Provide interlock wiring between supply, return and exhaust fans and electrical wiring for relays for temperature and pressure indication. Provide interlock wiring between refrigeration machines, pumps and condensing equipment as required for the specified sequence of operation and the refrigeration system integral controller(s). Do not provide interlock wiring if a dedicated digital output has been specified for the equipment or the sequence of operation requires independent start/stop.
Provide control wiring, conduit and connections for low temperature thermostats, high temperature thermostats, alarms, flow switches, actuating devices, control devices for temperature, pressure and flow indication, and point resets for the DDC control system.
Provide all other wiring required for the complete operation of the DDC control system. This includes but is not limited to:
Where 24VAC power is not provided as an integral part of the equipment, provide control power wiring between 120 volt AC/24 volt AC power transformers that are located in BACnet wall data enclosures to BACnet control components requiring 24 volts power for operation.
Line 120 volt AC power to TCC furnished control devices, i.e. flow meters, etc. (if applicable). The TCC shall retain the service of a licensed electrician and shall be responsible for the overall coordination of the above work.
Install all wiring raceway systems complying with the requirements of the National Electrical Code, and New York City Code. All corridor installations shall be installed in the Cable Tray or EMT. Provide EMT sleeves from the cable tray through the walls to above ceiling areas. Secured free air plenum rated cable is allowed to be run above the ceiling areas.
Input/Output Signal Control Wiring
RTD wiring shall be three-wire or four-wire twisted, shielded, minimum number 22-gage.
Digital Input and Output wiring shall be a minimum of number 18-gage.
Analog Input and Output control functions shall be a minimum of number 18-gage, twisted, shielded.
Thermistors shall be equipped with the manufacturers' calibrated lead wiring. This lead wire shall not be trimmed.
Low Voltage (24VAC) Power Wiring
Low voltage (24VAC) power wiring shall be minimum two-wire twisted AWG 16-2. Provide low voltage 24V AC power to each BACnet controller, as required, from 110V/24VAC transformers. Provide the required number of transformers based on the power requirements of each digital controller.
Low Voltage (24 VAC/VDC) Power and Signal Wiring
Low voltage power wiring (24 VAC) shall be minimum two-conductor stranded AWG 18 and sized for the amperage required. Low voltage signal wiring (24 VDC) shall be minimum two-conductor stranded AWG 18 and sized for the amperage required. Low voltage wiring may be combined within one cable if acceptable to the practices of the manufacturer to which the cable is connected.
Control Transformers (120VAC/24VAC)
The TCC shall provide control transformers conforming to the following specifications:
Single-phase general purpose, individually wall-mounted in NEMA 1 enclosures.
Dry type, two-winding type, self-cooled.
Ratings and quantities complying with the control system requirements and in conformance to:
a. New York State Code Requirements
Manufactured and tested in accordance with the latest applicable ANSI, NEMA, and IEEE Standards. UL listed and bear the UL label.

Control transformers shall be designed for continuous operation at rated kVA with normal life expectancy per ANSI C57.96.
Each transformer shall be over-current protected through the use of either a fuse or circuit breaker.
Splices

Splices in control power wiring and signal wiring cables shall not be allowed. Terminations shall be in accessible locations. Free air run cables shall be harnessed with cable ties as specified herein.
Conduit and Fittings
1. Where conduit is utilized for Control Wiring, Control Cable or Transmission Cable: Electrical metallic tubing (EMT) shall be provided with compression fittings. Conduit shall be cold rolled steel, zinc coated or zinc-coated rigid steel with threaded connections.
2. Outlet Boxes (Dry Location): Sheradized or hot-dipped galvanized drawn steel suited to each application, in general, four inches square or octagon with suitable raised cover.
3. Outlet Boxes (Exposed to Weather): Threaded hub cast aluminum or iron boxes with gasket device plate.
4. Pull and Junction Boxes: Size according to number, size, and position of entering raceway as required by National Electrical Codes. Enclosure type shall be suited to location.
Surface Mounted Raceway for Control Wiring, Control Cable or Transmission Cable
1. Metal raceway shall be of a two-piece design with a base and snap-on cover.
2. Raceway and all components shall be listed by Underwriters Laboratories
3. Manufacturers
   a. Mono-Systems, Hubbell Inc., Wire Mold Co or Panduit
   b. Single Channel: Wire Mold V700, Hubbell Inc. 750 Series, Mono-Systems SMS700, or Panduit PMR5/PMR7
c. Dual Channel: Wiremold V4000, Wiremold DS4000 Series, Hubbell Inc. 4000 Series or Mono-Systems SMS4200 or Panduit PMR40.
d. Surface mounted Raceway V2000BC
Relays
Relays other than those associated with digital output cards shall be general purpose, enclosed plug-in type when mounted within an enclosure. Relay configurations which are also acceptable include assemblies which house relay contacts within their own enclosure which is mounted externally on an enclosure. Number of contacts and operational function shall be as required.
Solid State Relays (SSR): Input/output isolation shall be greater than 10E9 ohms with a breakdown voltage of 1500V root mean square or greater at 60 Hz. The contact life shall be 10 x 10 E6 operations or greater. The ambient temperature range of SSRs shall be -20 to +140°F. Input impedance shall not be less than 500 ohms. Relays shall be rated for the application. Operating and release time shall be for 100 milliseconds or less. Transient suppression shall be provided as an integral part of the relay.
Contactors: Contactors shall be Definite Purpose specifically designed for the heating, ventilating, air conditioning, and refrigeration industry (HVACR) and suitable for the switching of single or three phase loads as applicable.

2.10 DDC HARDWARE IDENTIFICATION

Automatic Control Valve Tags
For valves, etc., use metal tags with a 1½" minimum diameter, fabricated of brass, stainless steel or aluminum. Attach tags with chain of same materials. For lubrication instructions, use linen or heavy duty shipping tag.
Tag valves with identifying number and system. Number valves by floor level, column location and system served.
Prepare lists of all tagged valves showing location, floor level, tag number, use. Prepare separate lists for each system. Include copies in each maintenance manual.
Wire Tags
All conductors or cables in all pull boxes, control panels, devices and terminal strip cabinets shall be tagged. Provide wire Tags as per Division 16.
Conduit Tags

Provide tagging or labeling of conduit so that it is always readily observable which conduit was installed or used in implementation of this Work.
Miscellaneous Equipment Identification
Screwed-on, engraved black Lamicoid sheet with white lettering on all control panels and remote processing panels. Lettering sizes subject to approval.
Inscription, subject to review and acceptance, indicating equipment, system numbers, functions and switches.
For panel interior wiring, input/output modules, local control panel device identification.
All I/O field devices (except space sensors) that are not mounted within the controller panel shall be identified with name plates.
All I/O field devices inside the controller panel shall be labeled.
The identification shall match all documentation and identify the function (i.e. mixed air temperature sensor).
Calibration settings shall be clearly marked with paint or indelible ink. Each terminal strip termination shall be tagged with an identification that matches the control drawings.
The outside of each DDC controller panel shall be identified with a phenolic label with black lettering on white background, matching the identification name shown on the drawings.
Affix plastic labels on each starter and equipment automatically controlled through the Control System. Label shall indicate the following:

CAUTION This equipment is operating under automatic control and may start at any time without warning.

All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 2" of termination with a cable identifier and other descriptive information.
Permanently label or code each point of field terminal strips to show the instrument or item served.
Identify all other control components with permanent labels. Identifiers shall match record documents. All plug-in components shall be labeled such that removal of the component does not remove the label. Identify all equipment and panels. Identification shall be with labels describing equipment and panel use function. Labels shall be engraved with contrasting text using bakelite, plastic or metal material. Labels shall be permanently glued or mechanically fastened.
Label each control valve and control damper actuator assembly (excluding VAV zones).
Coordinate numbering sequence with other Division 15 labeling requirements.
All wires and cables shall be identified with permanent markers or wire tag at controller. Wire designations at controllers shall describe the device termination point and function. Also provide control wiring diagram within terminal controller enclosure. Label all input and output field devices as labeled on control diagram.

2.11 Scheduling Functions:

A. Applications Editors. Each DDC Controller shall support full screen editing of all system applications. TCC shall provide editors for each application at DDC Controller(s). The applications shall be downloaded and executed at the appropriate DDC Controller(s).
Controller. TCC shall provide a full screen editor for each type controller and application that shall allow the operator with proper password to view and change the configuration, name, control parameters, and system setpoints.
Scheduling. TCC shall provide the capability to schedule periods. Each of these schedules shall include the capability for start and stop actions. Each schedule may consist of up to (10) events. Each schedule shall consist of the following:
a. Weekly Schedule. Provide separate schedules for each day of the week.
Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. This exception schedule shall override the standard schedule for that day. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed it will be discarded and replaced by the standard scheduled for that day of the week.
Holiday Schedules. Provide the capability for the operator to define special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be

able to define the length of each holiday period.
Equipment Coordination. TCC shall provide a full screen editor that allows equipment to be grouped for proper operation as specified in the sequence of operations.

2.12 CUSTOM APPLICATION PROGRAMMING FEATURES

TCC shall provide the software tools, approved by the AEOR to create, modify, and debug custom application programming.
The Temperature Control Contractor shall provide to the Authority a licensed copy of the following proprietary software that is required to program the custom application controllers. This software in turn shall be provided to the New York City. Provide a licensed copy of each of the following applicable packages: Schneider Electric Smart Structure software, Johnson Controls BACnet software, Honeywell's Spyder software, DisTech's BACnet GFX software, Siemens BACnet, Alerton BACnet Tool Set, Automated Logic BACnet Tool Set or the equivalent custom application controller software. Each control manufacturer shall be approved by the Authority's AEOR. The Temperature Control Contractor shall employ the software tool used to program the custom application controllers in the BACnet control system. A copy of these software tools shall be used and maintained by the Authority as required, properly overseeing the TCC commissioning.
The operator shall be able to create, edit, and download custom programs at the same time that all other system applications are operating. The system shall be fully operable while custom routines are edited, compiled, and downloaded.
The programming language shall be English language oriented and be based on the syntax of programming languages such as BASIC. It shall allow for free form or fill-in-the-blank programming. Alternatively, the programming language can be graphically-based using function blocks as long as blocks are available that directly provides the functions listed below, and that custom or compound function blocks can be created.
A full screen, character-based editor/programming environment shall be provided at the Portable Operator's Terminal (POT). The editor shall be cursor/mouse-driven and allow the user to insert, add, modify, and delete code from the custom programming. It shall also incorporate word processing features such as cut-paste and find-replace.
The programming language shall allow independently executing program modules to be developed. Each module shall be able to independently enable and disable other modules.
The editor/programming environment shall have a debugging/simulation capability that allows the user to step through the program and to observe any intermediate values and/or results. The debugger shall also provide error messages for syntax and execution errors.
The programming language shall support conditional statements (IF/THEN/ELSE/ELSE-IF) using compound Boolean (AND, OR and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
The programming language shall support floating-point arithmetic using the following operators: +, -, /, x, square root, and xy. The following mathematical functions shall also be provided: natural log, log, absolute value, and minimum/maximum value from a list of values.
The programming language shall have pre-defined variables that represent clock time, day of the week, and date. Variables that provide interval timing shall also be available. The language shall allow for computations using these values.
The programming language shall have the ability to pre-define variables representing the status and results of the System Software, and shall be able to enable, disable, and change the values of BACnet objects in the system. All programming tools shall be compatible with Tridium Niagara operating system (for integration into possible future network). Provide license copy of all programming tools to Authority.

2.13 RACEWAY MATERIALS AND CONDUITS

The Temperature Control Contractor is responsible for assuring that conduit size and quantity, size and type is suitable for the equipment supplied with a maximum fill of sixty percent. The Temperature Control

Contractor shall review the proper installation or each type of device with the equipment supplier.
All new conduits shall be concealed when installed in finished areas. Conduits shall be concealed in crawl spaces, above suspended ceilings and within walls. All conduits shall be installed parallel to building lines. The proper connector shall be used and properly installed to insure the integrity of the conduit system as a grounding means.
All pull or junction boxes shall be mounted in a readily accessible location. Junction or pull boxes shall be galvanized finished sheet steel of Code thickness and of ample size to properly enclose the conductors and to allow inspection of the contents. Junction boxes shall have plain sheet steel screw-attached covers. All pull and junction boxes shall have the cover marked indicating the function of the contents.

2.14 WIRING - GENERAL

Cable shall be suitable for use in conduits and ducts above and below ground and exposed installation in cable tray runs. Cable shall be suitable for operation in a wet or dry location with alternatively wet and dry conditions.
The design ambient temperature for cable shall be 40°C. Maximum ambient earth temperature shall be considered 20°C.
Cable shall have a service life equal to the design life of the installation, which is expected to be 20 years, at the design voltage and current rating and while subjected to environmental conditions.
Conductors shall be Class B, concentric stranded copper, tin-coated.
Insulation shall be fire-retardant, heat-resistant, oil-resistant, moisture-resistant, and ozone-resistant thermosetting compound rated for 90°C maximum conductor temperature under normal operating conditions.
Single-conductor and multi-conductor cables shall have an overall jacket made of the thermosetting compound with similar properties as insulation. Jacket and insulation construction and physical properties shall be in accordance with ICEA S-19-81, and S-68-514.

2.15 POWER CABLES (By Division 26 Contractor)

Power cable shall be No. 12 AWG minimum and may be Metal Clad Cable (Type AC) with ground conductor as allowed by Code.

2.16 CONTROL CABLES

Electronic instrument wire and cable shall be 300-V insulation class, single-twisted pair, multi-twisted pairs and triads, with individual pair and overall shield. No. 16 or 18 AWG conductor material shall be Class Concentric stranded copper annealed coated, insulated with a thermosetting compound with flame-retardant characteristics, and it shall be provided with an overall jacket of thermosetting compound.

2.17 TERMINAL BLOCKS

Each terminal block shall be uniquely identified. These identifications shall correspond to wiring diagram. Provide fire-retardant marking strips of the terminal blocks for external connections.

2.18 ENCLOSURES

For all input/output devices/controllers that require field interface devices, these devices where practical shall be mounted in a field DDC Controller panel. All other field interface devices shall be mounted at the point of field interface in a separate enclosure suitable for the location. The Temperature Control Contractor shall provide an enclosure that protects the device(s) from dust, moisture, conceals integral wiring and moving parts. DDC controller panels shall contain power supplies for sensors, interface relays and contactors, safety circuits, and I/P transducers.
The DDC controller enclosure shall be of steel construction with baked enamel finish; NEMA 1 rated with a hinged door and keyed lock. The enclosure shall be sized for twenty percent spare mounting space. All locks

shall be keyed identically.
All wiring to and from the DDC controller panel shall be to screw type terminals. Analog or communications wiring may use the panel as a raceway without terminating. The use of wire nuts within the panel or on any DDC Controller input or output wiring is prohibited.
All wiring within the panel shall be run in plastic wire way to give a neat and workmanlike appearance.

PART 3 - EXECUTION

3.1 INSTALLATION

The installation of the control system shall be made by the manufacturer or approved franchised dealers. See Quality Assurance Requirements.
Install the complete DDC systems of temperature control, as noted on the Drawings and as specified. Provide all necessary relays, mounting brackets, switches, digital controllers, control wiring and accessories required, even though not specifically called for, so as to result in complete workable systems.
Install all room sensors and thermostats at 7'-0" above the finished floor.

Electrical Work

Division 26 Electrical Contractor to provide power supply wiring from power source to power connection at unit control panels including starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer. Temperature Control Contractor to provide control wiring as required and necessary for a complete operation. Interlock wiring between electrically operated equipment and between equipment and field-installed control devices shall be provided by the Temperature Control Contractor.

Control Wiring

Install control signal and control power wiring without splices between terminal points. Install in neat workmanlike manner, securely fastened. Install raceways, boxes, cabinets, electronic, building wire, cables, and signal cable in accordance with National Electrical Code and the requirements of Division 26.
Install all wiring raceway systems complying with the requirements of the National Electrical Code, and New York City Code. All Corridor installations shall be installed in the Cable Tray or EMT. Provide EMT sleeves from cable tray through the walls to above ceiling areas. Secured free air plenum rated cable is allowed above ceiling areas.

3.2 DDC Control System INSTALLATION - EXAMINATION

Verify that systems are ready to receive work.
Beginning of installation means installer accepts existing conditions.
The project plans shall be thoroughly examined for control device and equipment locations, and any discrepancies, conflicts, or omissions shall be reported to the Authority for resolution before rough-in work is started.
The Temperature Control Contractor shall inspect the site to verify that equipment is installable as shown, and any discrepancies, conflicts, or omissions shall be reported to the Authority for resolution before rough-in work is started.
The Temperature Control Contractor shall examine the drawings and specifications for other parts of the work, and if head room or space conditions appear inadequate or if any discrepancies occur between the plans and his work and the plans for the work of others, he shall report such discrepancies to the Authority and shall obtain written instructions for any changes necessary to accommodate his work with the work of others.

3.3 GENERAL INSTALLATION REQUIREMENTS

Install all control components in accordance with manufacturer's instructions and recommendations.
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 Lamicoid nameplates on cabinet face.
After completion of installation, test and adjust control equipment. Submit data showing calibration, setpoints and final adjustments of controls.
Install equipment, piping, wiring, cable trays, etc. parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.
Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
Install all equipment in readily accessible location as defined by Chapter 1, Article 100, Part A of the NEC or by NYS Code.
Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.4 ELECTRICAL SYSTEM INSTALLATION

Comply with all New York State Code Requirements.
Install low voltage power in conduit in the following locations consistent with local building code allowances.
Mechanical rooms.
Electrical rooms.
Vertical risers (exception: fire-rated continuous shafts; for example telephone closets).
Open Areas where the wiring will be exposed to view or tampering.
Control wiring shall be installed above the corridor ceiling in Cable Tray or EMT. Provide EMT sleeves from the cable tray through the walls to above ceiling areas. Secured free air plenum rated cable is allowed to be run above the ceiling area in offices, classrooms and PA spaces.
Conceal conduit within finished shafts, ceilings and wall as required. Install exposed conduit parallel with or at right angles to the building walls.
Where Class 2 wires are in concealed and accessible locations including ceiling return air plenums, approved cables not in raceway may be used provided that:
Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
All cables shall be UL-listed for application, i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose.
Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).
Where Class 2 wiring is run exposed, wiring to be run parallel along a surface or perpendicular to it, and neatly tied at 3m (10 ft.) intervals.
All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wire-to-wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
Plug or cap all unused conduit openings and stub-ups. Do not use caulking compound.
Route all conduits to clear beams, plates, footings and structure members. Do not route conduit through column footings or grade beams.
Set conduits as follows:
Expanding silicone fire-stop material sealed watertight where conduit is run between floors and through walls of fireproof shaft.

Oakum and lead, sealed watertight penetration through outside foundation walls.
Cap open ends of conduits until conductors are installed.
Where conduit is attached to vibrating or rotating equipment, flexible metal conduit with ground conductor with a minimum length of 18 inches and maximum length of 36 inches shall be installed and anchored in such a manner that vibration and equipment noise will not be transmitted to the stationary conduit.
Where exposed to the weather or in damp or wet locations, waterproof flexible conduit shall be installed. Installation shall be as specified for flexible metal conduit.
Provide floor, wall, and ceiling plates for all conduits passing through walls, floors or ceilings. Use prime coated cast iron, split-ring type plates, except with polished chrome-plated finish in exposed finished spaces.
Wires are to be kept to a minimum of three (3) inches from hot water, steam or condensate piping.
Where wires leave the conduit system, they are to be protected by plastic insert or bushing.
All wiring in concrete walls or floors shall be run in rigid conduit.

3.5 TEMPERATURE AND HUMIDITY SENSOR AND THERMOSTAT INSTALLATION

Temperature and humidity sensors and thermostats shall require no field calibrations.
Temperature and humidity sensor and thermostats assemblies shall be readily accessible and adaptable to each type of application in such manner as to allow for quick, easy replacement and servicing without special tools or skills.
Temperature sensor strap-on mountings, utilizing helical screw stainless steel clamps, shall only be permitted on hot water piping up to 2 inches. All other water temperature sensors shall be in wells.
Outdoor installations shall be of weatherproof construction or in appropriate NEMA enclosures. These installations shall be protected from solar radiation and wind effects. Protective shield shall be stainless steel.
Thermostat and Sensor Guards: Each thermostat and sensor installed in THE Living Museum shall be provided with a slotted metal guard, wire guard or perforated guard designed for heavy-duty use which shall be fastened in place. Thermostat and sensors in all occupied areas in intermediate and high schools shall be equipped with slotted metal guard, wire guard or perforated guard designed for heavy-duty use which shall be fastened in place. Perforated guard shall be manufactured by Shaw-Perkins Inc. Series 16. Top, front, and bottom faces shall be 16-gage minimum with 1/8" perforations on 3/16" staggered centers. Finish shall be white or tan baked enamel. Cover sides and mounting frame shall be 14-gage minimum solid steel. Guard shall mount directly to wall and enclose thermostat or sensor. 18-gage minimum slotted steel thermostat guards shall be manufactured by Westwood Products, Inc. Top, front, and bottom faces shall be constructed of 18-22 gage minimum steel with finish of beige or white baked enamel finish. Guard shall mount directly to wall and enclose thermostat or sensor. Provide eight-tumbler lock, two sets of matching keys for each guard, and mounting hardware. Provide solid anchoring per the manufacturer's requirements.
Sensors in ducts shall be mounted in locations to sense the correct temperature and/or humidity of the air only and shall not be located in dead air spaces or positions obstructed by ducts, equipment, and so forth. Locations where installed shall be within the vibration and velocity limit of the sensing element. Ducts shall be securely sealed where elements or connections penetrate ducts to avoid measuring false conditions.
All sensors measuring temperatures in pipes larger than 2 inches in diameter or in pressure vessels shall be supplied with wells properly fabricated for the service. Wells shall be non-corrosive to the medium being measured and shall have sufficient physical strength to withstand pressures and velocities to which they are subjected. Wells shall be installed in the piping at elbows where piping is smaller than the length of the well to affect proper flow across the entire area of the well.
Thermo-well-mounted sensors shall include thermal conducting compound to ensure good heat transfer to the sensor.

3.6 FLOW SWITCH INSTALLATION

Install using a threadolet in steel pipe. In copper pipe use C x C x F Tee, no pipe extensions or substitutions allowed.
Mount a minimum of five pipe-diameters upstream and one pipe-diameter downstream or two feet whichever

is greater, from fittings and other obstructions.
Install according to manufacturer's instructions.
Assure correct flow direction and alignment.
Mount in horizontal piping – flow switch on top of the pipe.

3.7 ACTUATOR INSTALLATION

Mount and link control damper actuators per manufacturer's instructions.
To compress seals when spring return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
Valves - Actuators shall be mounted on valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following manufacturer's recommendations.

3.8 CONTROL VALVE INSTALLATION (AS APPLICABLE)

Valve submittals shall be coordinated for type, quantity, size, and piping configuration to ensure compatibility with pipe design. The equipment manufacturer or the mechanical field contractor shall install all valves.
All control valves shall be installed so that the stem position is not more than 60 degrees from the vertical up position or as directed by the valve manufacturer, whichever is the most limiting.
Valves shall be installed in accordance with the manufacturer's recommendations.
Control valves shall be installed so that they are accessible and serviceable, and such that actuators may be serviced and removed without interference from structure or other pipes and/or equipment.
Isolation valves shall be installed such that control valve body may be serviced without draining the supply/return side piping system. Unions shall be installed at all connections to screwed type control valves.
Provide tags for all control valves indicating service and number. Tags shall be brass, 1½" in diameter, with 1/4" high letters. Securely fasten with chain and hook. Match identification numbers as shown on approved controls shop drawings.

3.9 CONTROL DAMPER INSTALLATION (dampers are field furnished by tcc and installed by mechanical contractor)

Article does not apply to factory furnished equipment.
Damper submittals shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.
Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure 1/4" larger than damper dimensions and shall be square, straight, and level.
Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be equal ±1/8".
Mechanical contractor shall follow manufacturer's instructions for field installation of control dampers.
Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.
Mechanical contractor shall install extended shaft or jackshaft per manufacturer's instructions. (Typically, a sticker on the damper face shows recommended extended shaft location. Attach shaft on labeled side of damper to that blade.)
Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to assure proper operation. On multiple section assemblies, all sections must open and close simultaneously.

Provide a visible and accessible indication of damper position on the drive shaft end. The orientation of the blades shall be indicated by the Mechanical Contractor by notching the end of the damper shaft in the direction of the blades.
Mechanical contractor shall support ductwork in area of damper when required to prevent sagging due to damper weight.
After installation of low-leakage dampers with seals, mechanical contractor shall caulk between frame and duct or opening to prevent leakage around perimeter of damper.

3.10 LOCATION

Outdoor air sensors shall be mounted on the building's north face directly in the outside air. Install these sensors such that the effect of heat radiated from the building or sunlight is minimized. Install the outside air humidity and CO2 sensors adjacent to the outside air temperature sensor.
Field enclosures shall be located immediately adjacent to the controller panel to which it is being interfaced.

3.11 PROTECTION

The Temperature Control Contractor shall protect all work and material from damage by his/her work or workers, and shall be liable for all damage thus caused.
The Temperature Control Contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted by the AEOR/Authority's Representative. The Temperature Control Contractor shall protect his/her work against theft or damage, and shall carefully store material and equipment received on-site that is not immediately installed. The Temperature Control Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.12 FIELD QUALITY CONTROL

All work, materials and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this Section.
The Temperature Control Contractor shall continually monitor the DDC Control System field installation for code compliance and quality of workmanship.
The Authority's Project Officer shall arrange for field inspections by local and/or state authorities having jurisdiction over the work.
The Temperature Control Contractor's work shall be commissioned by the Temperature Control Contractor and witnessed by Authority representatives (Project Officer, and Commissioning Authority (CxA)).
Evidence of factory calibration and bench testing is required to be provided by the manufacturer and the Temperature Control Contractor. The Temperature Control Contractor shall provide certification from the manufacturer that controller, sensor, and actuator component testing has been completed. Copies of reports shall be made available within one week of request of copy. The Temperature Control Contractor shall test project specific database software routines and provide a written test report before downloading at the site for start-up, point to point, and basic function testing. The Temperature Control Contractor shall utilize the Portable Operator's Terminal (POT) to demonstrate the full functionality of the Temperature Control Contractor's work.

3.13 START-UP POINT-TO-POINT AND BASIC FUNCTIONAL TESTING

Upon completion of component or system installation, the Temperature Control Contractor shall initiate comprehensive point-to-point and basic functional testing. Factory calibration and bench testing will not be considered acceptable alternates to onsite field testing.
Start-up/Point-to-Point Scope
Test all end field devices through proper input/output to the Portable Operator's Terminal (POT).

Testing must be complete, detailed and documented on approved point-to-point verification forms.
All field calibration must be done with high quality instrumentation. Test instrumentation selected for calibrating field devices shall be suitable for application. Instruments shall display current (within the past 12-months) NIST traceable calibration sticker. Associated instrument calibration certificates shall be made available within 24 hours of request for copy.
Provide testing and documentation criteria.
Field device and functionality
Verify all field devices installed are properly sized or ranged for anticipated operating range. Verify devices are adjusted for correct position, orientation and full range.
Conductor Integrity
i) Test all wiring continuity from field devices to correct input/output.
Conductor Termination
i) Verify all device wire terminations are per submittal package.
ii) Verify all input/output wire terminations are correct.
iii) Verify field devices communicate to the Portable Operator's Terminal (POT).
Conductor to Output
i) Test linear-scaling calibration of every analog output point.
Device Calibration
i) All field devices are to be field calibrated. All thermistor sensors shall be tested for accuracy in the field or at the factory prior to shipment (when integral with NIST traceable calibration).
ii) Calibration must be done at or close to normal operating conditions.
Field Calibration Criteria

Space Temperature	± 1°F
Air Temperature–Unitary	± 1°F
Fluid Temperature	± 1°F
Air Flow Rate	± 5%
Liquid Flow Rate	± 5%
Differential Pressure	± 3%
Gage Pressure	± 5%
Relative Humidity	± 2%
CO2 Monitor	± 5% mid-range
Refrigerant Monitor	± 5% at 50 PPM

The Temperature Control Contractor shall completely check out, calibrate, and test all connected hardware and TCC supplied software to insure that the system performs in accordance with the approved specifications and sequences of operation submitted. The Special Inspector and/or EOR shall witness all testing performed by the Temperature Control Contractor.
The Temperature Control Contractor shall be responsible for all testing, repair, and retesting as outlined in this specification.
Complete records shall be kept of all tests and test reports. Records shall be made available to the DASNY Representative and/or project EOR for inspection and approval. Records shall be turned over to the Authority at the end of the work phase.
The Temperature Control Contractor shall notify the Authority at least five (5) days prior to testing in order that Authority's representatives (Project Officer and CxA) may witness such tests.
Demonstrate to the Authority's Project Officer and CxA approved operation and acceptance testing of the complete system.
Field Test: When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. All testing, calibrating, adjusting and final field tests shall be completed by the Temperature Control Contractor. Provide a crosscheck of each control point within the system by making a comparison between the control command and the field-controlled device. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power. Submit the results of functional and diagnostic tests and calibrations to the Authority (Project Officer and CxA personnel) for final system acceptance.

I. Sensors and other devices supplied with calibration certificates indicating prior factory calibration to reference standards that are traceable to NIST, shall not be adjusted in the field without the explicit consent of the Authority's Representative.

J. Comprehensive functional performance testing shall be performed on every installation or modification to the control system. The Temperature Control Contractor shall test and document all logic and control sequence statements for accomplishing each specific control function as detailed in the approved sequence of operation per Section 15985. The Temperature Control Contractor shall record each process and corresponding results. Documentation will include names of test personnel and final test dates.

K. Demonstrate the complete system to the Authority's Representatives (Project Officer and CxA personnel) to verify compliance with the project specifications. Failure to comply with the specified information shall constitute non-performance of the contract. The Temperature Control Contractor shall submit written justification for each item that he is unable to comply with.

3.14 START-UP AND TESTING

The Temperature Control Contractor and the Manufacturer's technical representative shall start-up, test, and set all parameters as directed by the Authority's Project Officer. The Temperature Control Contractor and the Manufacturer's technical representative shall demonstrate compliance with all requirements herein. All damaged or malfunctioning TCC supplied software shall be replaced.

A. Specially trained personnel in the direct employ of the Temperature Control Contractor shall perform final adjustments.

3.15 POINT VERIFICATION

To verify end-to-end operation of the system, the Temperature Control Contractor shall provide a hard copy of Points Summary Listing to the Authority's Project Officer and CxA personnel for each part or system to be placed in warranty. The Temperature Control Contractor shall additionally provide a print screen (via the POT) of the process display showing real time dynamic point information for all points on the subsystem(s) to be accepted.

3.16 SEQUENCE VERIFICATION

The Temperature Control Contractor shall notify the Authority's Project Officer and CxA personnel of systems that perform all specified sequences. The Project Officer and CxA personnel shall verify all sequences of operation and place the system into warranty acceptance test.

The warranty acceptance test shall be of 120 hour duration (which need not be contiguous) demonstrating the Sequence of Operation's occupied functionality and the system shall perform as specified.

During the 120 hours, the DDC Control system shall not report any system fault diagnostics from the system under test.

During occupied periods, DDC control loops, under test, shall maintain control of the process variable within the following tolerances relative to the applicable setpoint:

Duct Static Pressure	± 0.3-inch WC
Pump Head Pressure	± 10% of control range
Duct Temperature Loops	± 2.0°F
Room Temperature Loops	± 1.0°F
Pipe Temperature Loops	± 2.0°F
Duct Humidity	± 2% rated error of the Transmitter
Room Humidity	± 2% rated error of the Transmitter

The Temperature Control Contractor shall provide a hard copy printout of the process variable, process variable setpoint and control loop output percentage for the period of two hours prior to occupancy to 2 hours after occupancy with samples taken every 15 minutes. If required, TCC shall utilize chart recorder to show

the trending information.

3.17 ACCEPTANCE PROCEDURE

Upon completion of the installation, the Temperature Control Contractor shall start-up the system and perform all necessary calibration and testing to ensure proper operation of the project mechanical systems. See previous Articles for complete testing requirements.
The TCC shall schedule a hardware demonstration and system acceptance test to be performed in the presence of the Authority (Project Officer and CxA personnel). The acceptance testing is defined as demonstrating the sequence of operations as specified and/or as indicated on the Drawings. The Temperature Control Contractor shall perform all tests prior to scheduling the acceptance test and hardware demonstration to insure the overall system is ready for inspection and observations. During the completion of entire system commissioning by the Temperature Control Contractor (TCC), the TCC shall demonstrate to the Authority's Representative (Project Officer and CxA personnel) that the control systems function as designed.
When the system performance is deemed satisfactory in whole by these observers, the system parts will be accepted for beneficial use and be deemed substantially complete.
The control systems will not be accepted as meeting the requirements of Completion until all tests described in this specification have been performed to the satisfaction the Authority (Project Officer and CxA personnel). Any tests that cannot be performed due to circumstances beyond the control of the Temperature Control Contractor may be exempt from the Completion requirements if reported as such in writing to the Authority's representative. Such tests shall then be performed as part of the warranty.
The control system shall be properly commissioned prior to acceptance. The Temperature Control Contractor shall coordinate with others (including mechanical, electrical and test and balance) to properly start up and verify the operation of the system. Provide as-built documentation as specified.
Punch List and Deficiency Resolution
Within one (1) business day of deficiency notification, the Temperature Control Contractor shall resolve or provide written response indicating the earliest possible time and date the deficiency can and will be resolved.
Control deficiencies discovered during the commissioning process shall be rectified and retested. The Temperature Control Contractor shall bear all cost impacts.

3.18 DOCUMENTATION

3.18.1 DRAWINGS

The drawings shall be on AutoCAD (or in .dxf format). In every appropriate case, drawings shall be to scale and shall include:
Equipment layouts showing arrangement of internal components and wiring terminal blocks.
Equipment mounting and installation requirements.
Dimensioned physical drawings of all equipment.
System schematic diagrams.
Wiring diagrams.
Wiring connection diagrams shall include terminal blocks, wire designations, and circuit descriptions. The Temperature Control Contractor shall incorporate the terminal block numbers in the design drawings accordingly.
Should any error or inconsistency appear in the drawings, specification, or contract, or should the Temperature Control Contractor be uncertain as to the work, the Temperature Control Contractor shall, before proceeding with the work, inform the Authority's AEOR and Project Officer of same in writing and then proceed with work as directed by the Authority's AEOR or Project Officer in writing.

3.18.2 MANUALS

General: Provide maintenance manuals in accordance with the Contract Documents and as modified herein.
Provide five (5) copies of each manual and one (1) electronic copy of the complete operations and maintenance manual
Hardcopy Manuals shall be standard size and provided in hard back 3-ring loose-leaf binders. Electronic Copy shall be on USB memory drive and contain the AutoCad Format submittal drawings and pdf format copies of the product data sheets and supporting documentation.
Submit one (1) copy of each type of manual (electronic and hardcopy) to the AEOR. After review and approval, assemble other copies and submit for record.
Manuals shall be completed and in Authority's possession prior to Authority's acceptance and at least ten (10) days prior to instruction of operating personnel.
Contents of O&M Manuals
Provide a Table of Contents.
Include the following information in the Maintenance Manual in an Introduction section following the Table of Contents:
Alphabetical list of all system components, with the name, address, and 24-hour phone number of the company responsible for servicing each item during the first year of operation.
The Temperature Control Contractor's name, address and telephone number.
Name, signature and title of Temperature Control Contractor's representative responsible for preparation of technical manual.
Date of issuance of manual and revision number.
The Temperature Control Contractor's job control number.
Include the following information as a minimum in the sections Number 1, "General".
Valve tag list. (Coordinate with Mechanical Contractor. Use similar format or add onto the procedure initiated by the Mechanical Contractor).
Proper lubricants and lubricating instructions for each piece of equipment, the date when lubricated, and the recommended frequency of lubrication.
Table of multi-conductor cable tag number and corresponding system and building, floor or area served.
Charts showing normal operating conditions and points of high and low limit alarms.
Routine preventive maintenance procedures and corrective diagnostic trouble shooting procedures.
Parts list with manufacturer's catalog numbers and manufacturer's order information.
Installation instructions for each piece of equipment installed under this division.
List of ordinary and special tools, operating materials and supplies and test equipment recommended for operation and servicing.
Detailed description of modifications made to standard catalog equipment.
Contents of DDC Control System Manual
Prepare a separate binder for DDC Control System with sections for the following components:
General.
Custom Interface Application Documentation.
Toolset Application used to configure/program the controllers
BACnet products and equipment.
In addition, submit the following:
Electronic versions of AutoCAD (most current release or .dxf format) drawing files for all drawing submittals.
Plans, schematics and riser diagrams shall be printed on sheets large enough to be legible and folded to fit in binders.
A CD-ROM record copy of all submittal data.
Explanations of operator functions.
Computerized printouts of all data file construction including all point processing assignments, physical terminal relationships, flowcharts of program, etc.
Provide a manual including revised as-built documents of all materials required under the paragraph "Submittals" on this specification.
Manufacturer's Literature

General: Provide manufacturers literature of proper preventative and comprehensive maintenance for all items of equipment and components.

3.18.3 SPARE PARTS AND TOOLS

A list of recommended spare parts, accessories, and consumable supplies shall be provided. These spare parts are intended to be stocked at the site and will be used for normal operation, preventative maintenance, and minor repairs. Each item on the list of spare parts shall include a description, manufacturer, manufacturer's part number, recommended stock quantity, recommended vendors, unit price and delivery. A list of recommended special tools, equipment, and accessories as required for both initial installation and maintenance shall be provided. Each item shall include a description, manufacturer, part number, recommended quantity, recommended vendors, unit price, and delivery.

3.19 TRAINING

The Temperature Control Contractor shall provide competent instructors to give full instruction (minimum 40 hours) utilizing specified manuals, as-built documentation and the on-line help utility to designated personnel (Custodian and DOE Maintenance Representative) in the adjustment, operation and maintenance of the equipment installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. In addition, training shall be repeated quarterly during the warranty period, each a minimum of (8) hour sessions. Temperature Control Contractor shall submit training program with submittal for the Authority's AEOR's approval.
Since the Department of Education may require additional personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Temperature Control Contractor. If such training is required by the Department of Education, the TCC will be contracted at a later date. Temperature Control Contractor shall provide description of available local and factory customer training to the Department of Education for their review and consideration.
Following completion of the Temperature Control Contractor commissioning, demonstrate entire system operation to the DASNY representative as well to the complex engineering and maintenance personnel to the satisfaction of the Authority's Project Officer and the CxA personnel.

3.19.1 OPERATOR TRAINING

Provide instruction to operating personnel in accordance with the Contract Documents. The following general requirements are in addition to those in other Sections:
Instruct Owner's operating personnel in proper starting sequences, operation, shut down, and maintenance procedures, including normal and emergency procedures.
Instruct Owner's operating personnel in proper use of system scheduling procedures.
Instruction shall be by personnel skilled in operation of equipment. Instruction for major equipment shall be by equipment manufacturer's representatives.
Reference instructions contained in the Operating and Maintenance Manuals. Instructions cannot be substituted for manuals.
Provide equipment and materials required for classroom training.
All training performed shall reference site specific installation examples whenever possible. Training shall utilize the approved O&M manuals, as-built documentation, and the on-line help utilities.
Operator training shall include:

1. Sequence of Operation review
2. Use of Human Machine Interface (HMI)
3. Download and initialization of DDC controllers
4. Use of portable operator's terminal
5. Troubleshooting of sensors (determining bad sensors)

Submit course outline and operating manual for approval (by the Authority's AEOR prior to scheduling training. The training shall encompass as a minimum the following:

Basic Windows – Windows 10 Training or latest version
Overview of Control strategies for all DDC Control systems
Overview of installation of BACnet products
Use of the Portable Operator's Terminal Device (POT)
Troubleshooting of input devices, i.e., bad sensors
Sequence of operation review
Sign on - sign off using POT directly-connected to DDC controller.
Commanding of points, keyboard and mouse mode
Use of dialogue boxes and menus
System initialization

3.20 CLEANUP

At the completion of the work, all equipment pertinent to this contract shall be checked and thoroughly cleaned, and all other areas shall be cleaned around equipment provided under this contract. Clean the exposed surfaces of tubing, hangers, and other exposed metal of grease, plaster, or other foreign materials. Daily, upon final completion of work in an area, vacuum and/or damp wipe all finished room surfaces and furnishings.
At the completion of work at the end of each day, remove from the building, premises, and surrounding streets, etc. all rubbish and debris resulting from the operations and leave all equipment spaces clean and ready for use. The Temperature Control Contractor shall clean up all debris resulting from its activities daily. The Temperature Control Contractor shall remove all cartons, containers, crates, etc. under his/her control as soon as their contents have been removed. Waste shall be collected and removed by the Temperature Control Contractor at no cost to the Authority.
At the completion of work, all equipment furnished under this Section shall be checked for paint damage, and any factory finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

PART 4 – SCHEDULE

4.1 POINT SCHEDULES

Digital Input/Output (I/O) points which are required are herein defined as those hardware and software points needed to achieve the described sequence of operation, and as shown on the Point Lists, and as described and/or shown on the contract drawings, and as described in all specification sections. The DDC point requirement is cumulative in its effect so as to be more complete and inclusive than any one source. The points shall be monitored, displayed, and adjusted at the POT. The TCC, vendors, equipment manufacturers and all other providers of controls shall review the contract documents in their entirety for a complete understanding of the equipment details.
B. Points of control or features which are not scheduled on the Point Schedule and which are required to accomplish the specified sequence of control must be provided as if contained within the required list of points.

PART 5 – INTERDISCIPLINARY/FUNCTIONAL PERFORMANCE TESTING

5.1 DIGITAL CONTROL SYSTEM FUNCTIONAL PERFORMANCE TESTING (FOR BACnet DDC WITH STAND-ALONE BACnet PROJECTS)

The Temperature Controls Contractor shall use the Portable Operator's Terminal laptop, connected to the BACnet controllers to monitor, control and run all of the following Commissioning Checklists.

Note that all references to “BACnet Scheduler” and “Scheduler” in the Functional Performance Tests are to mean the local scheduler that each controller is to be furnished with. There is no central scheduler.

6.1 SEQUENCES OF OPERATION

Refer to the Drawings for the Sequences of Operation.

END OF SECTION 23 09 00

SECTION 23 20 10

HVAC PIPING

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. This Section is to coordinate with and be complementary to the General Conditions, General Requirements and Supplemental General Requirements, wherever applicable to Mechanical and Electrical Work.

B. Section 21 00 00 - Special Requirements for Mechanical and Electrical Work shall apply.

1.2 DESCRIPTION OF WORK

A. The Work includes providing of all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all piping as shown on the Drawings and hereinafter specified.

1.3 QUALITY ASSURANCE

A. "Manufacturers"-Firms regularly engaged in manufacture of pipe whose products have been in satisfactory use in similar service for not less than ten (10) years.

B. Provide pipe whose performance, under specified conditions, is certified by the manufacturer.

1.4 SUBMITTALS

A. Section 21 00 00 - Special Requirements for Mechanical and Electrical Work shall apply.

1.04 SUPPLEMENTAL SUBMITTALS

A. Shop Drawings: Submit schedule showing pipe or tube weight, fitting and joint type for each piping system; size, location and feature for each piping specialty, expansion compensation, hanger and support.

1. Grooved joint coupling and fitting product submittals shall be specifically identified with the applicable manufacturer’s style or series number.
2. Submit the underground oil piping protection system design (cathodic protection by sacrificial anodes or impressed current) for approval.

3. Provide shop drawings of all HVAC lines including but not limited to showing all diameters, pitch, cleanouts, traps, routings, terminations, shut-off valves, vents, riser drains, etc.

B. Certifications

1. Welding Certifications: Submit reports as required for piping work.
2. Brazing Certifications: Submit reports as required for piping work.
3. For expansion bolts installed in concrete, submit ICC certification for use in cracked concrete.

1.5 COORDINATION

A. Section 21 00 00 - Special Requirements for Mechanical and Electrical Work shall apply.

1.6 WARRANTY

A. Section 21 00 00 - Special Requirements for Mechanical and Electrical Work shall apply.

PART 2 - PRODUCTS

2.1 PIPE

A. All pipe shall be new, free from scale or rust, of the material and weight specified under the various services. Each length of pipe shall be properly marked at the mill for proper identification with name or symbol of manufacturer.

B. All steel piping, except where otherwise rated, shall be standard or extra strong weight, in conformance with the ASTM A-53 Grade A seamless, for piping 2" and larger, as manufactured by National Tube Division, Republic Steel Corp., or approved equal. Piping shall be ASTM A120 continuous butt weld, for piping less than 2".

C. All brass piping shall be standard or extra heavy weight 85% red brass semi-annealed seamless drawn, in conformance with the ASTM B-43, as manufactured by Anaconda, American Brass Co., Chase Brass and Copper Co., or Revere Copper and Brass, Inc.

D. All copper tubing shall be of weight as required for service specified, with conformance with ASTM B-88 for Types "L" and "K" tubing, as manufactured by Chase, Anaconda, Revere, or approved equal. Tubing and fittings shall be thoroughly cleaned with sand cloth and treated with an approved non-corrosive water washable flux conforming to ASTM-B813 before solder is applied.

E. All galvanized steel piping shall be standard or extra strong weight, as specified, in conformance with the ASTM A-53 Grade B. Pipe shall be hot-dripped zinc-coated with Prime Western smelter and not wiped.

F. Generally, unless otherwise specified, joints in steel piping of sizes 2 inches and under shall be screwed, and all sized 2-1/2 inches and over shall be welded or flanged. Brass pipe shall be screwed 2 inches and smaller and flanged 2-1/2 inches and over. Copper tubing shall be silversoldered or 95-5 solder as herein specified.

G. Screwed Piping

1. All connections to apparatus with screwed piping shall be made with 250 pound brass seat unions.

2. All screwed nipples shall be Schedule 80 nipples.

H. Welding Piping

1. All fittings for welded piping shall be as manufactured by Tube 'Turn, Grinnell, Bonney Forge or equal as approved by the Architect. The fittings shall be of the same weight and material as the piping to which they are attached.

2. For piping 2-1/2" and larger, full size branch connection shall be made with manufactured welding tees, branch connections for less than full size, shall be made with welding tees or with Weldolet forged branch outlet fittings. Fishmounting, shaped nipples, and stubbing not permitted.

I. Welding outlet fittings shall be Weldolets as manufactured by Bonney Forge, Inc., or approved equal 2 and smaller branches shall be made with thredolets as made by Bonney Forge or approved equal.

J. Weld ells shall have a center line radius not less than diameter of the pipes.

K. All flanges shall be welding neck flanges ANSI B16.5 ASTM 181 Grade I. all systems, except where otherwise noted - 150 lbs. Class, forged steel.

L. Instrumentation connections 3/4" and smaller on all systems shall be provided by welding threaded 2000# forged steel half couplings to the pipe.

M. All pipe to be welded shall be cut off clean and beveled. All welding shot shall be removed.

N. Composition of welding electrodes shall be in accordance with manufacturer's recommendations.

O. Pipe welding shall comply with the provisions of the latest revision of the applicable code, whether ASME Boiler and Pressure Vessel Code, ANSI Code for Pressure Piping B31, or such state or local requirements as may supersede codes mentioned above.

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

Q. Before any operator shall perform any pipe welding, also submit the operator's qualification record in conformance with provisions of the code having jurisdiction, showing that the operator was tested and certified under the Procedure Specification as before mentioned.

R. Assume responsibility for the quality of welding done and repair or replace any work not in accordance with these specifications.

S. In addition, all pipe welding procedures and procedures for qualification of pipe welding operators shall comply with the requirements of the American Welding Society.

T. Cut weld test plugs at locations selected at random by the Architect. The test plugs shall be tested by the testing agency approved for this project. Failure of the test plugs to meet the standards of the specified codes and agencies shall result in the complete removal and replacement of the joint and retesting of the operator who performed the welding. The removal and replacement of the joints shall be at no additional cost to the owner.

U. Pipe Schedule: Pipe for the various services shall be as follows:

Service	Material	Schedule
Drain	Copper	Type K
Cold Water	Copper	Type K
Hot Water (Heating)	Steel Copper	40 or standard Type L
Branch runouts to radiation	Copper	Type L
Branch runouts to radiation	Steel	40
Refrigerant	Copper Tubing	Type ACR
Vent (water discharge)	Copper Tubing 1/4" Type "L" above ground	(soft)

V. The Contractor shall have the option to use Type K copper or Type L copper for hot water piping up to and including 2".

W. All welders shall be certified welders.

2.2 FITTINGS

A. Fittings shall be specified under "Fitting Schedule" for various services.

B. Welding fittings shall be of the same material and schedule as the pipe to which they are welded. Welding elbows shall be long radius pattern unless clearance conditions necessitate the use of standard radius pattern. Welding fittings shall be as made by Tube-Turn.

C. Fittings shall be of material conforming to the following schedule:

Steel Welding Fittings	ASTM A-106
Malleable Iron Fittings	ASTM A-197
Cast-Iron Fittings	ASTM A-126
Brass Fittings	ASTM B-62
Solder Fittings	ASTM B-88

D. All fittings used at expansion loops or bends shall be extra heavy.

E. Cast-iron, malleable-iron and bronze fittings shall be of Crane manufacturer or approved equal.

F. Flanges shall be raised face, of the same weight as the fittings in each service category. All flanges shall be drilled to "US Standard" hex nuts and washers. Bolting shall conform to ASTM 193 Grade B-7, threads Class 7 fit. Nuts shall be semi-finished hexagonal, ANSI B18.2 ASTM A194 Grade 2H.

G. Unions - Unions 2 inches and smaller shall be screwed. Unions 2-1/2 inches and larger shall be flanged. Screwed unions on steel pipe, unless otherwise specified, shall be of malleable iron with bronze ground seats suitable for 300 pounds W.S.P. Screwed unions on copper or brass pipe shall be brass, ground joint suitable for 300 pounds W.S.P. Flanged unions shall be malleable iron for steel pipe, and brass for copper or brass pipe, gasket type suitable for 150 pounds W.S.P. Unions shall be as manufactured by Crane or approved equal.

H. Brass pipe threads shall be cut with special brass threading dies, and the joints shall be made up with lubricant. Strap wrenches, or equivalent, shall be used in making up brass pipe. Wrenches which gouge or scar the pipe will not be used.

I. Water washable flux conforming to ASTM B8313. Solder for each solder-type fitting shall be of 95% tin and 5% antimony or silver solder, as specified herein. Refrigerant piping joints shall be made with silver solder.

J. Unless otherwise specified, all flanged joints shall be fitted with Manville or equal ring gaskets designed for the intended service.

K. Fitting Schedule: Fittings for the various services shall be as follows:

Service	Size	Material	Weight	Type
Drain	ALL	Galv. M.I.	150#	Screwed
	ALL	Wrought Copper	125#	Solder
Cold Water	ALL	Bronze	125#	Brazed
	ALL	Wrought Copper	125#	Solder
Hot Water (heating)	2”& Below	C.I.	125#	Screwed
		Wrought Copper	125#	Solder
	2”& Above	Steel	Sch.40	Welding
Refrigerant	ALL	Wrought Copper	300#	Silver Solder
Vent (water discharge)	ALL	Wrought Copper	125#	Solder

2.3 PIPE HANGERS AND SUPPORTS

A. Provide necessary structural members, hangers and supports of approved design to keep piping in proper alignment and prevent transmission of injurious thrusts and vibrations. In all cases hangers, brackets, etc., shall not be supported from metal decking and/or Terracotta slab construction, supplementary steel welded to building structure shall be provided. All hangers and supports shall be capable of screw adjustment after piping is erected. Hangers supporting piping expanding into loops, bends and offsets shall be secured to the building structure in such a manner that horizontal adjustment perpendicular to the run of piping supported may be made to accommodate displacement due to expansion. All such hanger's shall be finally adjusted, both in the vertical and horizontal direction, when the supported piping is hot, or chilled, as required. Hangers in contact with copper or brass pipe shall be copper plated steel.

B. Pipe hangers shall be the clevis and pipe roll types, except where otherwise noted.

PIPE HANGER SCHEDULE

		MAKE AND MODEL		
				Carpenter
Grinnell	F & M & Paterson Pipe	Type of Hanger	Fig. No.	Fig No.
2" & smaller (steel)	Clevis Hanger	260	239	100
2" & smaller (copper)	Adjustable Wrought Iron	CT-65	364	100 CT
2-1/2" to 4" (steel)	Adjustable Swivel Pipe Roll	174	2729	16
5" & above	Two Rod Roller Hanger	171	170	142

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

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

E. All vertical piping shall be anchored by means of heavy steel clamps securely bolted or welded to the piping, and with end extension bearing on the building. Provide copper clad pipe clamps for the support of the copper hot water risers.

F. All vertical piping shall be guided at each floor by use of clamps fastened to building structure. Provide 360° protective saddle at guides. Saddles shall be fastened to pipe or insulation.

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

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

I. For all makeup water and insulated refrigerant piping, provide "Insuishield" as made by Insulcoustic Corp. or pipe covering protection shield C & P Fig. 265P with steel □ shield min. 9 inches long, with vapor barrier jacket. For hot-water heating piping 2 inches and smaller, same as above. For hot-water heating piping 2-1/2 inches and larger, provide steel pipe covering protection saddles C & P Fig. 353 series.

J. Piping in trenches shall reset or hang from angle iron cross supports provided by the Contractor with two coatings of red led primer and final coat for black asphaltum paint. K. Hanger rods shall be of the following diameters:

Pipe Size		Rod Diameter	Max. Spacing
1-1/4 inch & below		3/8 inch	6'-0"
1-1/2 and 2 inch		3/8 inch	10'-0" (copper 8'-0")
2-$^1/_2$ inch			10'-0"
3 inch	1/2 inch		
4 inch			
5 inch	5/8 inch	12'-0"	

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

M. Where additional steel is required for the support of hangers, furnish and install same subject to the approval of the Architect. Piping and ductwork shall not be supported from concrete slab construction at ceiling.

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

O. Lateral bracing of horizontal pipe shall be provided where required to prevent side sway or vibration. The lateral bracing shall be of a type approved by the Architect and shall be installed where directed by the Architect. P. All heavy piping, such as:

L. Any combination of closely spaced pipes weighing more than the equivalent of above or 15 lb.

per lin. ft., shall be supported at all cross points with overhead floor beams by fastening to the flange of such beams with steel clamps or other suitable means.

M. Where such heavy piping runs parallel with the floor beams properly designed auxiliary steel must be provided. The spacing of such auxiliary steel supports shall in no case be greater than the spacing of the floor beams running perpendicular to the corrugations of the permanent slab steel forms.

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

2.4 ANCHORS

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

B. Anchors shall be fabricated and assembled in such a form as to secure the piping in a fixed position. They shall permit the line to take up its expansion and contraction freely in opposite directions away from the anchored points; and shall be so arranged as to be structurally suitable for particular location, and line loading. Submit details for approval.

PART 3 - EXECUTION

3.1 INSPECTION

A. Perform flexibility analysis of the final piping configuration as required by ANSI B31.1. Insure that the resultant stresses are within the limits for the respective pipe materials and that the resultant forces and moments imposed on the anchors and guides do not exceed the Joist and Truss Manufacturers stated limitations.

B. Upon completion of the flexibility analysis, notify the Architect of additional loops, anchors or guides required to adequately protect the piping system.

C. Examine areas and conditions under which all products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to the Architect.

3.2 PREPARATION

A. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed. Correct inadequacies including (but not limited to) proper placement of inserts, anchors and other building structural attachments.

3.3 INSTALLATION

A. Coordinate with other work as necessary to interface installation of piping with other components of systems.

B. Provide and erect in a workmanlike manner, according to the best practices of the trade, all piping shown on the Drawings or required to complete the installation intended by these Specifications.

C. The Drawings indicate schematically the size and location of piping. Piping shall be set up and down and offset to meet field conditions and to provide adequate maintenance room and headroom in the Mechanical Rooms.

D. Study the General Construction Specifications and Plans, of the exact dimension of finished work and of the height of finished ceilings in all rooms where radiation, units, equipment or pipes are to be placed and arrange the work in accordance with the Schedule of Interior Finishes, as indicated on the Architectural Drawings.

E. All exposed piping shall be run perpendicular and/or parallel to floors, interior walls, etc. Piping and valves shall be grouped neatly and shall be run so as to avoid reducing headroom or passage clearance. Provide min. 7'-6" headroom under passageway in mech. equip. room All valves, controls and accessories concealed in furred spaces and requiring access for operation and maintenance shall be arranged to assure the use of a minimum number of access doors.

F. All pipe lines made with screwed fittings must be provided with sufficient number of flanges or unions to make possible any taking down of the pipes without breakage of fittings.

G. All piping shall be erected as to insure a perfect and noiseless circulation throughout the system. No bull head tees will be permitted.

H. All valves and specialties shall be so placed as to permit easy operation and access.

I. Provide proper provision for expansion and contraction in all portions of pipework, to prevent undue strains on piping or apparatus connected therewith. Provide double swings at riser transfers and other offsets wherever possible, to take up expansion. Arrange riser branches to take up motion of riser.

J. Approved bolted, gasketed, flanges (screwed or welded) shall be installed at all apparatus and appurtenances, and wherever else required to permit easy connection and disconnection. Screwed unions shall be used on piping 2" or less.

K. All piping connections to coils and equipment shall be made with offsets provided with screwed or welded bolted flanges so arranged that the equipment can be serviced or removed without dismantling the piping.

L. If, after plant is in operation, any coils or other apparatus are stratified or air bound (by vacuum or pressure), they shall be repiped with new approved and necessary fittings, air vents, or vacuum breakers at no extra cost. If connections are concealed in furring, floors, or ceilings, bear all expenses of tearing up and refinishing construction and finish, leaving same in as good condition as before it was disturbed.

M. Fittings shall be of the eccentric reducing type, where changes of size occur in horizontal piping to provide for proper drainage or venting. Steel pipe bends shall be made of the very best grade open hearth, low carbon steel, leaving a smooth uniform exterior and interior surface. Pipe bends shall be made with seamless steel pipe, having a minimum radius of not less than five (5) pipe diameters.

N. Tubing shall be erected neatly in a workmanlike manner. Bends in soft copper tubing benders to prevent deformation of the tubing in the bends. Approved seat-to-pipe threaded adapters shall be provided for junctions with valves and other equipment having threaded connections.

O. Vertical sections of main risers shall be constructed of pipe lengths welded together. No couplings shall be used.

P. The ends of all pipe and nipples shall be thoroughly reamed to the full inside diameter of the pipe and all burrs formed in the cutting of the pipes shall be removed.

Q. Piping shall be installed in accordance with the latest edition of the ASME Code for Pressure Piping.

R. All piping shall be concealed above furred ceilings in rooms where such ceilings are provided (except where specifically indicated otherwise on the drawings, or in walls or partitions, except as otherwise indicated.

S. Dissimilar piping shall be connected with dielectric connector as made by Ebco Company or approved equal.

T. Dielectric unions shall protect against the destructive effect of galvanic and stray current corrosion between dissimilar metals. Unions shall be rated for temperatures up to 210°F at 250 psig and shall conform to ANSI B16.39. End connections shall match the pipe to which they are connecting. Pipe threads shall be in accordance with ANSI B2.1. Dielectric unions shall be factory certified to withstand a minimum of 600 volts on a dry line with no flashover. Units shall be equal to Watts 3000 Series dielectric unions.

U. Piping at all equipment and control valves shall be supported to prevent strains or distortions in the connected equipment and control valves. Piping shall be supported to allow for removal of equipment, valves and accessories with a minimum of dismantling and without requiring additional supports after these items are removed.

V. Pipe nipples - Any piece of pipe 3" in length and less shall be considered a nipple. All nipples with unthreaded portion 1-1/2" and less shall be extra heavy. Only shoulder nipples shall be used. No close nipples will be permitted.

W. Screw threads shall be cut clean and true; screw joints made tight without caulking. No caulking will be permitted. A non-hardening lubricant shall be used. No bushings shall be used. Reductions, otherwise causing objectionable water or air pockets, to be made with eccentric reducers or eccentric fittings.

X. Pitch water piping upward one inch per 100 feet in direction of flow to ensure adequate flow without air binding, and to prevent noise and water hammer. Pitch drain piping 1/8 inch per foot

in the direction of flow. Branch connections to mains are to be made in such a manner as to prevent air trapping and permit free passage of air. To meet job conditions, mains shall set up to maintain headroom, and clear other trades. Provide oversized float operated automatic air vent (with valve). Avoid 90 deg. lift set-ups in supply lines by using 45 degree ells. Where 90 deg. lifts exceed 12" install automatic air vent in supply lines. All lifts in return lines shall be installed with automatic air vents. Pipe outlet of all automatic air vents to an open sight drain if the vent is concealed, or to within two feet of the floor within machine rooms. All water piping shall pitch back to low points for drainage. Low points shall be provided with 3/4 inch hose cocks.

Y. Provide drain valves at the heel of all interior main water risers. Provide drain valves at the heel of all perimeter water risers.

Z. Miscellaneous drains, vents, reliefs, and overflows from tanks, equipment, piping, relief valves, pumps, etc., shall be run to the nearest open sight drain or roof drain. Provide drain valves whenever required for complete drainage of piping, including the system side of all pumps.

AA. Provide domestic water connections from valved outlets to any equipment requiring same.

BB. All drain piping from condensate drain pans shall be properly trapped in accordance with the static pressures involved. Condensate drain piping sizes shall as shown in plans.

3.4 FIELD QUALITY CONTROL

A. Upon completion of installation of piping (partial or complete) test piping to demonstrate compliance with requirements. Where possible, field correct malfunctioning piping, then retest to demonstrate compliance. Replace piping which cannot be satisfactorily corrected. Refer to Section - Testing and Balancing.

3.5 CLEANING, FLUSHING, INSPECTING

A. Clean exterior surfaces of superfluous materials, and prepare for application of specified coatings (if any). Flush out piping systems with clean water before proceeding with required tests. Inspect each run of each system for completion of joints, supports and accessory items. Inspect pressure piping in accordance with procedures of ASME B31.

B. Hanger Adjustments: adjust hangers so as to distribute loads equally on attachments.

C. Support Adjustment: provide grout under supports so as to bring piping and equipment to proper level and elevations.

3.6 PAINTING

A. Upon completion of the installation, remove all protecting materials, all scale and grease and leave in a clean condition for painting.

END OF SECTION 23 20 10

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SECTION 23 21 23

HYDRONIC PUMPS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. This Section is to coordinate with and be complementary to the General Conditions, General Requirements and Supplemental General Requirements, wherever applicable to Mechanical and Electrical Work.

B. Section 21 00 00 - Special Requirements for Mechanical and Electrical Work shall apply.

1.2 DESCRIPTION OF WORK

A. The Work includes providing of all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all pumps as shown on the Drawings and hereinafter specified.

1.3 QUALITY ASSURANCE

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

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

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

1.4 SUBMITTALS

A. Refer to Section 21 00 00, "Special Requirements for Mechanical and Electrical Work", and submit shop drawings.

1.03 SUPPLEMENTAL SUBMITTALS

A. Product Data: Submit current accurate pump characteristic performance curves with selection points clearly indicated.

B. For the packaged pumping system, submittals shall include the following as a minimum: system design information sheet; description of system operation; packaged system dimension and general arrangement drawing; electrical power and control wiring diagram; pump material and construction drawing; pump curve showing design point; catalog information on valves, strainers and control components.

C. Shop Drawings: Schedule: Pump schedule showing pump specifications, application, layout and connections.

D. Wiring Diagrams: Submit manufacturer's electrical requirements for the power supply wiring to the packaged pumping system. Power supply wiring shall be provided by the Electrical Contractor. Submit manufacturer's wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory installed and portions to be field installed by the Temperature Control System Contractor.

E. Provide a set of manufacturer's warranties for all equipment supplied.

F. Maintenance Data.

1. Maintenance Manual

G. Certificate: Contractor's start-up and demonstration affidavit.

1.5 COORDINATION

A. Refer to Section 21 00 00, "Special Requirements for Mechanical and Electrical Work".

1.6 GUARANTEE

A. Refer to Section 21 00 00, "Special Requirements for Mechanical and Electrical Work".

1.05 WARRANTY

A. Packaged pumps shall have a manufacturer's 24 month parts and labor warranty and the VFD shall be warranted by the manufacturer for parts and labor for a period of 36 months. The installing contractor shall be responsible to secure the services of the manufacturer for warranty service and emergency repair during the first 24 months of the system operation (36 months for the VFDs). All warranties shall use Substantial Completion as the warranty start date. The warranty shall include parts, labor, and travel costs incurred by the manufacturer to provide factory authorized on-site services. Equipment submittals will not be approved until submission of the manufacturer's warranty indicating compliance with the above.

PART 2 - PRODUCTS

2.1 IN-LINE PUMPS-LONG COUPLED 2" DISCHARGE AND SMALLER

A. Furnish and install in-line pumps where shown on the plans and as specified.

B. The pumps shall be of the horizontal, oil-lubricated type, specifically designed and guaranteed for quiet operation. Suitable for 125# working pressure.

C. The pumps shall have a ground and polished steel shaft with a hardened integral thrust collar. The shaft shall be supported by two horizontal sleeve bearings designed to circulate oil. The pumps shall be non-overloading at any point on pump curve. Impellers shall be of bronze construction.

D. The motor shall be of the open, drip-proof, sleeve bearing, quiet-operating, rubber-mounted construction.

2.2 END SUCTION PUMPS

A. The casing and suction head of the pump shall be of cast iron material and end suction, vertical split type. Casing and suction head shall be equipped with 125# ANSI flanges. Pumps shall be assembled on heavy duty fabricated structural steel base plates, which bases must include drip rim with tapped drain connections which shall be piped to nearest floor drain. The impeller shall be of the enclosed type and shall be bronze. The impeller shall be statically and hydraulically balanced and keyed to the shaft. Efficiency and unit maximum BHP shall be quoted and guaranteed. Maximum head shall occur at and only at the no flow condition. The shaft shall be of steel material and removable shaft and shall be stainless steel. Bearings shall be single row, ball type and oil or grease lubricated. B. Pumps shall have replaceable case wear rings.

B. Pumps shall have capacities as scheduled on the Drawings. Pumps shall be selected to operate at or near their point of peak efficiency thus allowing for operation at capacities of approximately 25% beyond design capacity. In addition, the design impeller diameter shall be selected so that the design capacity of each pump (GPM and TDH) shall not exceed 90% of the capacity obtainable with maximum impeller diameter at the design speed for that model or as approved. C. Casings shall be provided with suitable steel lifting lugs.

D. Pump shall be drain down slightly on the foundation bolt nuts. Provide a form or dam around the contour of the bed plate. Pour grout through holes, provided for this purpose, in sufficient quantity to reach a level of 3/4" to 1" above the bottom of the bed plate. Pump bases are to be fully grouted. Allow grouting to set thoroughly, then proceed with pipe connections.

E. Seals to be capable to withstand system condition for water temperature and chemical treatment content as hereinafter specified under "Water Treatment".

PART 3 - EXECUTION

3.1 INSPECTION

A. Contractor shall examine location where pumps are to be installed and determine space conditions and notify Architect in writing of conditions detrimental to proper and timely completion of the work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install equipment where shown, in accordance with manufacturer's written instructions, and with recognized industry practices, to ensure that equipment comply with requirements and serve intended purposes.

B. Add concrete under structural members of pump base and grout around the base as required by manufacturer's written instruction.

C. Coordinate with other work as necessary to interfere installation of equipment with other components of systems.

3.3 FIELD QUALITY CONTROL

A. Upon completion of installation of equipment and after motor has been energized with normal power source, test equipment to demonstrate compliance with requirement. When possible, field correct malfunctioning units, then retest to demonstrate compliance. Replace units which cannot be satisfactory corrected. Refer to Section Test and Balancing.

B. All pump casings shall be hydrostatically tested at 1-1/2" times design working pressure. The pump manufacturer shall be responsible for his service department aligning in the field prior to start-up of all flexibly coupled units. Alignment shall be with dial indicator with accuracy of plus or minus .002 inches. The pump manufacturer must submit a written report certifying that the alignment work had been performed by his personnel and that the pumps are ready for operation.

END OF SECTION 23 21 23

SECTION 23 25 16

WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. This Section is to coordinate with and be complementary to the General Conditions, General Requirements and Supplemental General Requirements, wherever applicable to Mechanical and Electrical Work.

B. Section 21 00 00 - Special Requirements for Mechanical and Electrical Work shall apply.

1.2 DESCRIPTION OF WORK

A. The work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all water treatment and cleaning as shown on the drawings and hereinafter specified.

B. The Contractor shall engage the services of a water treatment contractor who shall provide a complete water treatment service. The service shall include furnishing and application of all chemicals, at least one visit a month to collect samples for chemical analysis at the water treatment company's laboratory, and all necessary inspection, adjustment, and maintenance of the chemical treating devices. Complete chemical control of the treatment shall be included. Reports shall be furnished to Architect after each visit.

C. Water treatment shall be applied concurrently with the operation of each circulating water system for a period of one year. An initial dose of treatment chemical shall also be applied immediately after each system is initially filled with water if operation is to be delayed after filling.

D. In addition to the chemicals indicated, slimicides and algaecides shall be provided as necessary. Chromate and phosphate will not be acceptable. All chemicals shall be approved by local and state agencies having jurisdiction.

E. The firm's water treatment laboratory shall be equipped to analyze water in accordance with the statement methods of the American Public Health Association.

F. Water treatment contractor shall provide chemical feeding devices during the period of this contract. At the termination of the contract, the treatment equipment shall belong to the Owner.

G. Provide a water treatment program for the following systems:

1. Hot water closed heating systems.

1.3 QUALITY ASSURANCE

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

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

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

1.4 SUBMITTALS

A. Refer to Section 21 00 00- Special Requirements for Mechanical and Electrical Work and submit shop drawings.

1.5 COORDINATION

A. Refer to Section 21 00 00- Special Requirements for Mechanical and Electrical work.

1.6 GUARANTEE

A. The Consultant Water Treatment Firm and the Contractor shall guarantee in writing, that the water systems and any component parts thereof, will experience no more than minimal scale formation, biocides**,** corrosion, pitting, algae and slime growth, for a period of one year from the date of Substantial Completion of this Project, when treated in strict accordance with the Water Treatment Firm’s recommendations. The initiation of the one-year warranty period shall not include the time prior to Substantial Completion. Water treatment shall be performed on the hydronic equipment as soon as it is filled with water. Bi-weekly testing and reporting of the test results shall continue for the one-year duration of the warranty period and also during any time period that the equipment is used for temporary heat.

1.06 MAINTENANCE

A. Extra Materials: Furnish a one-year supply of water treatment chemicals.

B Scope of Service: Provide chemicals and service program for maintaining optimum conditions in the circulating water for inhibiting corrosion, scale, biocides, and organic growths in the piping and equipment. Services and chemicals shall be provided for equipment and piping if they are used for temporary heat and for a period of one year from date of Substantial Completion, including the following:

1. Initial water analysis and recommendations.
2. Startup assistance.

3. Periodic field service and consultation. Field testing shall be done on a bi-weekly basis as soon as the system is filled with water and shall continue for one (1) year after Substantial Completion. For hot water condensing type boilers, the chemical treatment Contractor shall take the first water samples for biocide treatment within twenty-four (24) hours of completing the one hundred and twenty (120) hours Operational Test for the hot water heating system. Based on the initial hot water testing of the boilers, the chemical treatment contractor shall issue the proposed treatment plan for biocides and continue the field testing/monitoring/treatment of the hot water system for biocides for minimum intervals of every two (2) weeks during the first heating season.
4. Customer report charts and log sheets.
5. Laboratory technical assistance.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

1.08 PERFORMANCE REQUIREMENTS

A. Maintain water quality for HVAC systems that controls corrosion and build-up of scale and biological growth for maximum efficiency of installed equipment without posing a hazard to operating personnel or the environment.

B. Base chemical treatment performance requirements on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 CHEMICAL TREATMENT CLOSED HOT WATER SYSTEMS

A. Provide a Nitrite based material to maintain the following conditions in each closed water system.

	Chilled Water	Hot Water (250°F. max)
pH	7.5 - 9.0	7.5 - 9.0
Nitrite as NO2	300 - 400 ppm	300 - 400 ppm

2.2 CHEMICAL TREATMENT - CLEANING - DEGREASING

A. Provide a supervised program of cleaning and degreasing chemicals used in the specified systems prior to start-up. Sufficient chemicals shall be added to each system to establish a concentration of 120 ppm degreasing chemicals containing 20% dioctysulfocuccinate and a concentration of 240 ppm of cleaning chemical containing 15% polyacrilate and 25% diphosphonate in the water. Systems shall then be circulated for a minimum of 8 hours, dumped, flushed, and refilled,

with the correct corrosion inhibitors added for operation. Strainers are to be hand cleaned after flushing.

2.3 CHEMICAL FEED EQUIPMENT - HOT WATER

A. Provide a 5-gallon shot feeder including funnel, relief valve and air vent for intermittent feed of corrosion inhibitor across a suitable pressure drop in each closed system.

2.4 WATER TREATMENT CONTROL TESTING EQUIPMENT

A. Provide a test set complete with apparatus and chemical regents for the determination of phosphonate (ortho), pH (7.6 - 9.2), nitrite and any additional test as required by water treatment company.

2.5 CLEANING OF PIPING SYSTEMS

A. Preliminary Cleaning:

1. Clean new piping internally by flushing prior to the application of pressure tests and before the chemical cleanout procedures specified herein. Provide temporary strainers at the inlet to the hot water pumps

2. Block off and isolate circulating pumps, cooling coils, heating coils, during the preliminary flushing and draining process.

3. Thoroughly flush piping clear of foreign matter with City water under pressure, and then drain before proceeding with pressure testing for duration of eight (8) hours. Blow down accumulations of grit, dirt and sediment at each strainer and each low point in the piping systems.

4. Provide bypass flush valves and required piping to permit full circulation of water during the washout of the piping systems. Close shutoff and balancing valves on branch piping to the terminal equipment units during the washout operation to prevent water circulation through the automatic control valves.

B. Chemical Cleanout:

1. After completion of pressure testing, chemically clean internally each recirculating water system (including hot water).

2. Provide temporary connections with valves to fill the piping and remaining equipment with water for the purpose of draining piping and equipment after completion of the chemical cleanout procedure. Provide temporary blind flanges and/or caps to isolate the piping and equipment noted herein.

3. Provide temporary piping connections, valves, strainers, bypasses, and blank connections where required to clean out systems. Line each strainer basket with a fine mesh nylon screen and replace the screens at the end of each day's circulation until each system is

thoroughly cleaned.

C. Hot Water Heating System: Fill each system with City water; start circulation pump and vent high points manually until all air is released from the system.

1. All recirculating water systems, both open and closed, to be filled and flushed with a solution of a non-foaming chemical detergent, to remove all foreign matter. Circulate the solution for a minimum of 8 hours and drain as rapidly as possible to remove suspended matter. Flush the system with fresh water, drain a second time and refill. After final filling, the pH of the water must not exceed the pH of the fresh incoming water by more than 0.5 pH.

2. Introduce the chemical solution into the system gradually by injecting into the suction side of the circulating pump, or by means of a bypass chemical feeder located on the discharge side of the permanent hot water system circulating pump. Slowly raise and then maintain the temperature of the circulating water at 150°F by circulating through the hot water converter.

3. While the water is being heated and circulated, open each drain connection for a short flow. Repeat at hourly intervals. Replace any water drained during blowdown with chemical solution as required until air is eliminated from the system. The chemical cleanout procedure to be continuous in this manner for 3 full 8-hour periods.

4. At the conclusion of the chemical cleanout period, completely drain the entire system and allow to cool. Flush out with fresh City water prior to final activation of the system. Remove temporary equipment and strainers, reconnect permanent pump and replace items previously removed. D. Filling of Water Systems:
   a. After completion of the chemical cleanout, fill each water system with fresh water, air vent, and add chemical treatment.

   b. If the outdoor ambient temperature drops to 32°F., and the danger of freeze-up exists, drain water systems.

2.6 INTERNAL TREATING OF PIPING

A. This work shall include the internal protective coating of all distribution systems on this construction such as, but not limited to, hot water heating systems and components. The RidSludge treatment shall be applied by Heating Economy Services Co., Pelham, N.Y., Astro Pak Corp., Metuchen, N.J., Drew Chemical Co., N.J., or as approved equal.

B. This method of treating is to be applied to all piping supply and return and then back to the source of equipment.

C. The Contractor shall clean the piping for the purpose of removing lime, oil, grease, oxides and other wastes therefrom. After the removal of these impurities, a protective coating shall be applied to all inner surfaces, which will inhibit oxidation as well as protect the metals against impurities that may be present in the water. This coating shall be guaranteed for five years from date of

completion at no cost to the Owner, covering labor and materials. Valve-off heat exchangers to avoid coating surfaces.

D. The treating materials use for this purpose must have been in use successfully for at least five years in comparable systems.

E. It shall be compounded of non-corrosive, non-toxic, non-alkaline and non-injurious ingredients that have been investigated and reported as a "Neutral Compound" by a recognized engineering firm or laboratory, other than the submitting company's own laboratory. Brochures and unbiased test reports shall be submitted to the Architects within 90 days from job acceptance for approval. This treating firm shall show proof, that said firm has been established and accepted for this work, for a minimum of 10 years. The ingredients used shall have no deleterious effects on seals, 0-rings, glands, packing, etc.

F. It shall be the sole responsibility of the approved firm for the application of this process. He shall supply all labor, materials, and equipment for this purpose. A competent supervisor and/or equipment operator shall be kept at the site from commencement of his work until completion. None but experienced men shall provide treating of piping. Any repairs or servicing of components of these systems shall be done by the Contractor.

2.7 Glycol Feed Units

A. Furnish and install, as indicated on the plans and specifications, a prefabricated, prefabricated package water/glycol make-up system. The package shall consist of a painted steel frame, a high density polyethylene reservoir with removable lid, 120V regenerative turbine pump, union type isolation valves, silent check valve, a field adjustable pressure relief valve, suction wye-strainer with a stainless steel, 20 mesh screen, corrosion resistant adjustable leveling feet, schedule 80 CPVC suction manifold and 3045S discharge manifold, reed type low level switch, glycerin filled pressure gauge NEMA 4X control enclosure with adjustable pressure switch with visual range scale, and a standard three prong, 120V plug.

PART 3 - EXECUTION

3.1 INSPECTION

A. Contractor shall examine location where this equipment is to be installed and determine space conditions and notify architect in writing of conditions detrimental to proper and timely completion of the work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install water treatment equipment where shown or specified, in accordance with manufacturer's written instructions, and with recognized industry practices, to ensure that water treatment systems comply with requirements and serve intended purposes.

B. Coordinate with other work as necessary to interface installation of water treatment equipment with other components of systems.

C. Check alignment and, where necessary (and possible), realign shafts of motors and equipment within tolerances recommended by manufacturer.

3.3 CONTRACT DURATION

A. This contractor shall provide water treatment for a period of one year. All water systems shall be treated to maintain specified criteria for a period of one year.

3.4 FIELD QUALITY CONTROL

A. Upon completion of installation of equipment, and after motors have been energized with normal power source, test equipment to demonstrate compliance with requirements. When possible, field correct malfunctioning units, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected.

3.5 DEMONSTRATION

A. Preliminary Requirements: Provide the services of the field service representative of Water Treatment Company for the following:

1. Inspect each water treatment feeder installation prior to the addition of chemicals.
2. Supervise initial charging of the water system based on city water analysis.
3. Perform biweekly testing and submit test results starting as soon as the systems are filled with water and continue for one (1) year after Substantial.

B. Maintenance and Operation Training

1. Contractor shall prepare detailed, coordinated step-by-step maintenance and operations manuals covering all chemical analysis equipment and all other items and accessories.
2. As a part of the maintenance and operating instructions, review data in operating and maintenance manual, including preventative maintenance schedule and procedures, and procedures for obtaining repair parts and technical assistance. Demonstrate all phases of operation including analysis of the water, introduction of chemicals and all other items and accessories.

END OF SECTION 23 25 16

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SECTION 23 31 13

METAL DUCTS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. This Section is coordinate with and complementary to the General Conditions and Supplementary General Conditions of the work, wherever applicable to HVAC Work.

1.2 DESCRIPTION OF WORK

A. The work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all Sheet Metal Ductwork as shown on the drawings and hereinafter specified.

1.3 QUALITY ASSURANCE

A. Fabrication and installation shall be by a single firm specializing and experience in metal ductwork for not less than 10 years.

B. Comply with SMACNA (Sheet Metal and Air Conditioning Contractors National Association) recommendations for fabrication, construction and details and installation procedures, except as otherwise indicated.

C. Comply with ASHRAE (American Society of Heating Refrigeration and Air Conditioning Engineers) recommendations, except as otherwise indicated.

D. Compliance to SMACNA and ASHRAE is a minimum requirement. In case of disagreement between sheet metal work described in this Section and SMACNA or ASHRAE, the specification shall govern.

1.4 SUPPLEMENTAL SUBMITTALS

A. Product Data

1. Submit Shop Standards for metal ductwork including gages, materials, type of joints, sealing requirements, method of fabrication and reinforcing.
2. Submit manufacturer’s product data for factory-fabricated single wall round ductwork, duct sealant and cement, gasket materials, duct liner and sound traps; and installation instructions.
4. Submit product data for factory manufactured commercial Fire-Resistive Duct Assemblies.

B. Shop Drawings

1. Submit scaled layout drawings (3/8"=1') of metal ductwork and fittings including but not limited to duct sizes, locations, elevations, slopes of horizontal runs, wall

and floor penetrations, and connections, including location of connections. Show modifications of indicated requirements, made to conform to local shop practice and how those modifications ensure that free area, materials and rigidity are not reduced.

a. Layouts should include all the room plans, mechanical equipment rooms and penthouses.

2. Method of attachment of duct hangers to building construction with all the support details including methods for vibration isolation, cable hanging systems. For expansion bolts installed in concrete, submit ICC certification for use in cracked concrete.

3. Submit shop manufactured method of fabrication for Fire-Resistive Duct Assemblies.

5. Coordinate Shop Drawings with related trades prior to submission. Contractor shall provide shop drawings for all roof openings required for installation of HVAC systems. Roof opening shop drawings shall be dimensioned from the centerline of the nearest structural column and coordinated with the approved HVAC equipment, sheet metal shop drawings, framing plan, etc.

C. Quality Control Submittals

1. Duct Leakage Tests.

1.5 PRODUCT HANDLING

A. Protect shop fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Protect ends of ductwork and prevent dirt and moisture from entering ducts and fittings.

B. Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade and enclosed with waterproof wrapping.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR DUCTWORK

A. Furnish and install the size, connections and run of ducts as indicated on the drawings.

B. While the Drawings shall be adhered to as closely as possible, the Architect's right is reserved to vary the run and size of ducts during the progress of the work if required to meet structural conditions.

C. Install all ductwork in strict adherence to the ceiling height schedule indicated on the Architect's Drawings. Contractor shall coordinate with all trades to ensure all ductwork fits within the space allotted for this work given the other trades which share this space.

D. The sheet metal ductwork shall, whether indicated or not, rise and/or drop and/or change in shape to clear any and all conduits, lighting fixtures, plumbing and heating mains to maintain the desired

ceiling heights. And to provide adequate maintenance room and headroom in mechanical equipment rooms.

E. The ductwork shall be continuous, with airtight joints and seams presenting a smooth surface on the-inside and neatly finished on the outside. Ducts shall be constructed with curves and bends so as to affect an easy flow of air. Unless otherwise shown on the Drawings, the inside radius of all curves and bends shall be not less than width of ducts in plane of bend.

F. All rectangular ductwork, unless otherwise noted, shall be built from galvanized sheet steel and thoroughly braced and stiffened.

1. Provide 12" x 12" access doors for every 50'-0" run of supply and return air duct for cleaning purpose.

G. All outside air intake ducts between intake point and air handling unit or mixed air duct or plenum shall be aluminum construction with all joints sealed with a manufacturer approved sealer.

H. All air ducts exposed to the weather and not insulated shall be constructed of aluminum and shall be properly braced and supported and secured to the building construction. All seams shall be sealed with a manufacturer approved sealer.

1. The construction of ductwork shall be same as conventional ductwork except where transverse reinforcing angles not required, provide 1" x 1" x 1/8" black iron bracing angles matched angles at joint and 1" x 1" x 1/8" black iron between joints 4'-0" from joints.
2. Provide 1/8" thick gasket for all matched angles.
3. Edge of ducts shall be bent 1/2" over matched angles to obtain watertight seal.
4. Aluminum rivet angles to duct and seal with a manufacturer approved sealer.
5. Paint black iron angles after installation.

I. Provide G90 galvanic coating for all galvanized ductwork.

J. Provide all aluminum ductwork for all shower room, laundry room, toilets, outside air duct to air conditioning units and moisture laden exhaust ductwork.

K. Standard duct sealing requirements:
Seal class A shall be provided for all ductwork for all pressure classes. Conformance to NYCECC 403.2.9.1.1 shall apply

2.2 MATERIALS

A. Sheet Metal

1. Aluminum: ASTM B209, Alloy 3003, Temper H-14 sheet form with standard, one-side bright finish for ducts exposed to view and with mill finish for concealed ducts.

2. Galvanized Steel: Lock-forming quality; ASTM A653 G60 coating designation; mill-phosphatized finish for surfaces of ducts exposed to view.

3. Stainless Steel: ASTM A480, Type 316, sheet form with No. 4 finish for surfaces of ducts exposed to view; and Type 304, sheet form with No.1 finish for concealed ducts.

4. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized, sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

5. Tie Rods: Galvanized steel, 1/4" minimum diameter for 36" length or less; 3/8" minimum diameter for lengths longer than 36".

B. Gages of Metal for galvanized rectangular duct: Gages of metal shall be in accordance with Tables 2.1 through 2.28 of SMACNA HVAC Duct Construction Standards Third Edition - 2005. Duct shall be constructed to the pressure shown on the on the Drawings. The duct pressure classification shall default to the equipment external static pressure if the pressure levels are not shown on the Drawings. However, for ductwork upstream of chilled beams, displacement induction units and VAV boxes and outdoor ductwork, the Construction Class shall be 3-inch WC (inches of water column) or higher equipment external static pressure.

C. Hangers and Supports

1. Rod Type Hangers and Angles: Hot dip galvanized steel with 2 locking nuts in place.

2. Strap Hangers: Same material as ducts except that galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

3. Trapeze and Riser Supports: Steel shapes complying with ASTM A36. Same material as ducts.

4. Strap and Rod Sizes: Comply with SMACNA for sheet width and thickness and for rod diameters.

5. For ducts with a cross sectional area of 2 square feet or less, hangers shall be constructed of at least 1” by 1/16” steel strap. For ducts with a cross sectional area of over 2 square feet, hangers shall be constructed of at least 1” by 1/8” steel strap.

6. Expansion bolts for use in existing and new reinforced stone concrete slabs and concrete deck shall be as follows: Fully threaded, torque-controlled, wedge-type expansion anchor consisting of a high-strength threaded stud body, stainless steel expansion elements (clip, wedge), nut and washer. Expansion Bolts installed in concrete shall be in accordance with Appendix D of ACI 318 as modified by Sections 1908.1.9 and 1908.1.10 as per Section BC 1912 of the 2014 NYC Building Code.

a. “Trubolt+” as manufactured by ITW Ramset/Red Head
b. "Kwik Bolt 3” as manufactured by Hilti, Inc.
c. “Power Stud+ SD2” as manufactured by Powers Fasteners, Inc.

7. Cable Hanging Systems (Gripple): Cable Hanging Systems with adjustable mechanical devices compliant with SMACNA HVAC Duct Construction Standards Third Edition-2005 shall consist of ready-to-use factory tested kit comprising of cable and cable end options. Crimps shall be Factory installed. All cable hanger products shall be certified as SMACNA and UL listed. All cable hangers shall have a minimum of 4:1 safety margin over the listed Safe Working Load (SWL).

D. Miscellaneous Ductwork Materials

1. Sheet Metal Screws, Machine Bolts, Rivets and Nuts: Tinned, cadmium plated or rust resistant materials. Bolts shall be button-head stove bolts, 1/4" x 3/4" unless otherwise specified.

2. Concrete Inserts: Steel or malleable iron, galvanized; continuously slotted or individual inserts conforming with MSS SP-58, Types 18 and 19, Class A-B.

2. Beam Clamps: For ducts with a cross sectional area of 2 square feet or less, clamp shall be Caddy Catalog Number 4H-Series Fig 2. For ducts with a cross sectional area of over 2 square feet, clamp shall be Fee & Mason 255L with locking nut and 255S retaining strap.

3. Welding Studs: Erico Fastening Systems, capacitor discharge, low carbon steel, copper flashed.

4. Structural (carbon) Steel Shapes and Steel Plates: ASTM A36, shop primed.

5. Stainless Steel Shapes and Plates: ASTM A276 and ASTM A666.

7. Duct Sealant: Non-hardening, non-migrating mastic or liquid elastic sealant, type applicable for fabrication/installation detail, as compounded and recommended by manufacturer specifically for sealing joints and seams in ductwork in accordance with Article 2.02.A.3.

a. All adhesives and sealants used on the construction of ductwork shall comply with the South Coast Air Quality Management District (SCAQMD) Rule #1168; VOC limits shall comply with the limits indicated in LEED Version 3.0, Indoor Environmental Quality Section, Credit IEQ 4.1. Those limits correspond to an effective

date of the SCAQMD Rule #1168 of July 1, 2005, and Rule Amendment date of January 7, 2005.

8. Duct Cement: Non-hardening migrating mastic or liquid neoprene based cement, type applicable for fabrication/installation detail as compounded and recommended by manufacturer specifically for cementing fitting components, or longitudinal seams in ductwork in accordance with Article 2.02.A.3.

   a. All adhesives and sealants used on the construction of ductwork shall comply with the South Coast Air Quality Management District (SCAQMD) Rule #1168; VOC limits shall comply with the limits indicated in LEED Version 3.0, Indoor Environmental Quality Section, Credit IEQ 4.1. Those limits correspond to an effective date of the SCAQMD Rule #1168 of July 1, 2005, and Rule Amendment date of January 7, 2005.

9. Flexible Ducts: Either spiral-wound spring steel with flameproof vinyl sheathing, or corrugated aluminum; complying with UL 181. Where installed in unconditioned spaces other than return air plenums, provide 1" thick continuous flexible fiberglass sheath with vinyl vapor barrier jacket.

10. Welds: Weld material shall match ductwork material. Galvanized ductwork welds to be cleaned and painted with galvanizing repair paint conforming to ASTM A780.

2.3 DUCT PENETRATION THRU FLOOR

A. Provide 4" high and 4" wide concrete pad all around opening at duct penetration thru floors. Fill in space between duct and floor construction with fire proof mineral wool.

2.4 DRAIN PANS

A. Drain pans for cooling coils in built-up units shall be 14 gauge stainless steel with all welded seams and joints and shall be rigidly braced with brass stiffening angles.

B. Each coil section composing the coil bank of a built up unit shall have an individual drain pan extending 9" on both sides of the coil with a minimum 2" vertical lip downstream of the coil. The top edge of the lip shall be turned backward. The pans shall be connected with copper tube to permit drainage to the bottom drain pan. Pans shall be 14 gauge stainless steel and shall be welded and pitched to the drain.

C. Provide insulation under drain pans for cooling coils, consisting of 2" thick cork.

2.5 DRIP PANS

A. Provide copper pans and gutters under all equipment subject to leaks mounted above electrical equipment. Each copper pan shall be properly pitched and a drain outlet provided and piped, to drain. See "Drip Pans" under Section Special Requirements for Mechanical and Electrical Work.

2.6 INSTALLATION OF HVAC DEVICES

A. Installation of Smoke Detectors: Smoke detectors shall be furnished by contractor and shall be installed in ductwork under this Section. Provide access door to each smoke detector.

B. Installation of Dampers: Refer to Drawings and temperature control specification for smoke dampers and other automatic dampers, combination fire and smoke dampers, and install them in ductwork.

2.7 DUCT FABRICATION

A. Ducts shall be neatly finished on the outside with all sharp edges removed.

B. Inside surfaces shall be smooth with no projections into the air stream except where otherwise indicated.

C. Longitudinal joints shall be Pittsburgh lock at corners or Acme lock on flat surfaces double seams hammered tight and shall be located above the horizontal axis of the duct. A snap lock seam shall not be permitted as a substitute for the Pittsburgh lock at corners of ducts. D. Transverse joints shall be made airtight with all laps in the directions of air flow.

D. All fasteners and attachments shall be made of the same material as the ducts.

E. Furnish test wells 12" on the center horizontally and vertically in the suction and discharge duct of each fan. Test wells shall consist of a 1" x 3/4", 125 lb., bronze, screwed hex bushing, secured to the duct with a bronze hex locknut on the inside of the duct. A 3/4" x 2" long standard weight bronze, screwed nipple and cap shall be fitted to the housing on the outside of the duct.

F. All radius elbows shall have a minimum centerline radius of 1-1/2 times the width of the duct.

G. All square elbows shall have factory-designed and built double thick turning vanes. Shop fabrication vanes will not be approved. Where turning vanes are in conflict with the access doors to fire dampers. They shall be made movable, so that fire dampers, shall be accessible.

H. Dissimilar metals shall be connected with flanged joints made up with fiber or neoprene gaskets to prevent contact between dissimilar metals. Flanges shall be fastened with bolts protected by ferrules and washers made of the same materials as the gaskets. Where an aluminum duct is to be connected to a galvanized steel duct, the end of the galvanized steel duct shall be coated with heavy black asphaltum paint before connecting it to the aluminum duct.

I. Changes in shape and dimension shall conform to the following: Except where otherwise noted, for increases in cross-sectional area, the shape of the transformation shall not exceed 1" in 7". Except where otherwise noted, for reductions in area, the slope shall not be less than 1" in 4" but 1" in 7" preferred.

J. Ductwork for medium pressure systems shall conform to the following:

1. Medium pressure ductwork is an entire ductwork of AC units.
2. Duct construction shall consist of gauges and reinforcing framing specified in latest ASHRAE Guide for medium pressure ductwork or as per SMACNA Manual, but not less than the following weights and construction.

Construction for Rectangular Medium

Pressure Duct

Dimension of Longest Side Inches	Galvanized Sheet Gauge (All 4 Sides)	Transverse Reinforcing Between Joints and At Joints
Up thru 12	24	Inside slip joint, double S slip, welded flange, standing seam, flanged joint, pocket lock, compassion angle flanged joint with 11/4 x 1-1/4 x 1/8 angles. No tie rods required at joints. Joints max. on 8 ft. centers.
13 thru 18	24	Between Joints: 1 tie - rod at 48 in. intervals on centerline of ductside or without tie rods with 1 x 1 x 16 gauge angle @ 48 in. At Joints: Inside slip joint, double S Slip and welded flange, each with 1 x 1 x 16 gauge angle. Standing seam, flanged joint, pocket lock, companion angle flanged joint with 1-1/4 x 1-1/4 x 1/8 angles. Joints max. on 8 ft. centers.
19 thru 24	22	Between Joints: 1 tie rod @ 48 in. intervals on centerline of duct side or without tie rods with 1 x 1 x 1/8 angle @ 48 in. At Joints: Inside slip joint, double S slip and welded flange, each with 1 x 1 x 1/8 angle. Standing seam, flanged joint, pocket lock, companion angle flanged joint with 1-1/4 x 11/4 x 1/8 angle. Joint max. on 8 ft. centers.
25 thru 36	22	Between Joints: Without tie rods with 1 x 1 x $^1/_8$ angle @ 32 in. or 1-1/4 x 1-1/4 x 1/8 angle @ 40 in. At Joints: Inside slip joint, double S slip, welded flange, each with 11/4 x 1/8 angles. Standing seam, flanged joint, pocket lock, companion angle flanged joint with 1-1/4x 1-1/4 x 1/8 angles. Joint max. on 8 ft. centers.
37 thru 48	22	Between Joints: Without tie rods with 1-1/4 x 1-$^1/_4$ x 1/8 angle @ 30 in. At Joints: Inside slip joint, double S slip, welded flange, each with 1-1/2 x 1-1/2 x 1/8 angles. Reinforced standing seam, with 11/2 x 11/2 x 1/8 angles, companion angle flanged joint with 1-1/4 x 11/4 x 1/8 angles. Joints max. on 8 ft. centers.

3. Transverse reinforcing must be applied on all four sides and tied together at each corner by riveting, bolting or welding, to prevent air leakage and shall be installed with 1/8" thick gasket . Gaskets shall have overlapped corners and cove entire frame. Connecting angles shall be bolted to each other with stove bolts, spaced not more than 6" apart. In addition, each such angel frame shall be itself welded at the corners for rigidity. The longitudinal spacing of the transverse reinforcing between joints may necessarily be less than the spacings recommended in the table in order to conform to the selected length module.
4. In addition to the above, all medium pressure ductwork at supply fans, for a minimum of 30 ft. - 0 in. from supply fan shall have bracing, on each of four sides, as follows:

   Up to 60 inches On 2 ft. - 0 in centers
   Over 60 inches On 2 ft. - 0 in. centers, plus a longitudinal angle on sides over 60 inches.
5. All bracing angles shall be 2" x 2" x 1/8" and shall be tack welded or spot welded to

2.8 DAMPERS

A. At each main branch take-off and in such other locations where required to properly balance the low pressure system, furnish and install volume dampers of the opposed blade, multi-louvered type, which shall be operated by indicating quadrants and set screws, for adjusting the system.

B. For stainless steel, copper and aluminum ductwork provide dampers of same material as ductwork.

C. All dampers shall be made accessible from building construction. Access doors in building structure shall be furnished or provided as herein before specified.

D. Smoke dampers shall be installed at all smoke barriers within 2 ft. of the barrier and between any branch take off or duct outlet or inlet and the barrier.

2.9 FIRE DAMPERS

A. Clearly indicate fire damper location on shop drawings. Provide access doors in the ducts and furnish access doors or panels at building construction at each damper of sufficient size and type to permit inspection and replacement of linkage. Assume responsibility to coordinate all locations of duct access doors with the Contractor to conform with whatever architectural access openings may be necessary and furnish access doors or panels in building construction. Provide shop drawings indicating location of access panels or _doors for Architect's approval:

B. It is the intention of these plans and specifications to be complete. However, it is the responsibility of this Section, as being completely cognizant of ' local regulations, to determine where fire dampers are required and to advise the Architect/EOR prior to construction as to any discrepancies or questions in the plans or specifications.

2.10 ACCESS DOORS IN SHEET METAL WORK

A. Wherever necessary in ductwork, casings or sheet metal partitions, provide suitable access doors and frames to permit inspections, operation and maintenance of all valves, coils, humidifiers, controls, smoke dampers, smoke detectors, fire dampers, filters, bearings, traps, or other apparatus concealed behind the sheet metal work. All such doors shall be of double construction of not less

than No. 20 gauge sheet metal and shall have sponge rubber gaskets around their entire perimeter. Doors in insulated ducts of insulated casings shall have rigid fiberglass insulation between the metal panels.

B. All access doors in sheet metal ducts shall be hung on heavy flat hinges and shall be secured in the closed position by means of cast zinc clinching type latches. Where space conditions preclude hinges, use four heavy window type latches. Doors into ducts shall in general not be smaller than 18" x 18" except for access door to fire dampers which will depend on size of fire damper.

C. In no case shall access to any items of equipment requiring inspection, adjustment, or servicing require the removal of nuts, bolts, screws, wing nuts, wedges, or any other screwed or loose device.

D. Each sheet metal chamber shall have access doors for access to all parts of the system. Doors shall be fitted with cast zinc door latches, two per door. Latches shall be operable from both sides of casing. Hinges shall be extra heavy, zinc plated hinges, minimum of two per door. The doors shall be felted or provided with rubber gaskets so as to make them airtight. The doors shall be made with inner and outer shells 2 inches apart so that they may be properly insulated and properly operated. Doors shall be a minimum size of 20" x 48".

2.11 FLEXIBLE CONNECTIONS

A. All fan and air supply unit connections, both at inlet and discharge shall be made with material as hereinafter specified, so as to prohibit the transfer of vibration from fans to ductwork connecting thereto.

B. The flexible connections shall be a minimum of 12" long including bands using extra wide fabric as specified and held in place with heavy metal bands, securely attached, to prevent any leakage at the connection points.

C. Flexible connections shall be fabricated from the following materials unless otherwise required by Local Authorities.

1. Low Pressure Systems - neoprene coated glass fabric - 30 ounce/sq. yd.
2. Medium Pressure Systems - neoprene coated glass fabric - 30 ounce/sq. yd.

D. Flexible connections shall not be painted.

2.12 AIR INTAKE AND DISCHARGES

A. Air intake and discharge louvers and screens in the facade of the building shall be furnished and installed as per spec section 089119.

B. Air intake louvers where indicated in drawings, not in facade of building, such as behind building skin, shall be furnished and installed in this contract. Such louvers shall be minimum 14 gauge aluminum with maximum blade length between mullions of 4'-0". Provide weathertight joints between louver frames and masonry openings by means of flashing and/or caulking. Provide 1/2" mesh heavy aluminum wire screens. Provide drain pipe at duct plenum connection to louvers - plenum bottom and 6" up each side, joints and seams to be sealed with 3M EC-800, bottom pitched

to drain connection, drain to be trapped. Inside of outside air intake plenums to be painted with two coats of black asphaltum paint.

2.13 ACOUSTICAL PERFORMANCE SPECIFICATIONS - GENERAL

A. It is the intent of this Specification that noise levels due to air conditioning and/or ventilating equipment, ducts, grilles and registers, diffusers and air light fixtures, will permit attaining sound pressure levels in occupied spaces conforming to the following NC curves as explained in the ASHRAE Guide and Data Book.

Office and Conference Rooms	NC-35
Lobby	NC-40
Classrooms	NC-30
Lecture Halls	NC-30

B. Grilles, Registers, Diffusers

1. The maximum permissible sound power levels of air terminal devices when installed and operating per plans and specifications shall be as follows:

Maximum PWL re 10-12 Watts

Octave Band	NC-30	NC-35	NC-40
1	62	64	66
2	52	56	60
3	44	49	54
4	41	46	51
5	38	43	48
6	37	42	47
7	36	41	46

C. Sound Power Levels shall be tested in accordance with ASHRAE Standard 36-72.

2.14 SOUND TRAPS FOR DUCTWORK

A. Where indicated on the Drawings, provide in the ductwork packaged sound traps of proper models and sizes for the purpose of attenuating noise. Sound traps shall be as specified herein and shall conform with the requirements tabulated on the Drawings.

B. Construction

1. Rectangular Units: Fabricate casings with a minimum of 0.034-inch thick, solid galvanized ASTM A653 sheet metal for outer casing and 0.022-inch thick, ASTM A653 perforated galvanized sheet metal for inner casing.

2. Round Units:

a. Outer Casings:

1. ASTM A653 galvanized sheet steel

2. Up to 24” in Diameter: 0.034” thick

3. 26” through 40” in Diameter: 0.040” thick

4. 42” through 52” in Diameter: 0.052” thick.

5. 54” through 60” in Diameter: 0.064” thick.

6. Casings fabricated of spiral lock-seam duct may be one size thinner than that indicated.

b. Interior Casing, Partitions, and Baffles:

1. ASTM A653 galvanized sheet steel

2. At least 0.034” thick and designed for minimum aerodynamic losses

3. Sheet Metal Perforations: 1/8” diameter perforations for inner casing and baffle sheet metal.

4. Fill Material: Inert and vermin-proof fibrous material, packed under not less than 5 percent compression.

5. Erosion Barrier: Polymer bag enclosing fill and heat-sealed before assembly or Tedlar film liner as a fill protection.

6. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations.

a. Do not use nuts, bolts, or sheet metal screws for unit assemblies.

b. Lock form and seal or continuously weld joints.

c. Suspended Units: Provide factory-installed suspension hooks or lugs attached to frame in quantities spaced to prevent deflection or distortion.

d. Reinforcement: Provide cross or trapeze angles for rigid suspension.

C. Performance

1. The attenuation values obtained by the sound traps shall be not less than those tabulated on the Drawings. They shall be true attenuation values, only accomplished by the sound traps. These true attenuations shall not include any effects due to (1) end reflections, (2) room absorptions, (3) plenum absorption, (4) directivity, (5) beaming, (6) standing waves or (7) distance factors.

2. Adhesives, sealants, packing materials, and accessory materials shall have fire ratings not exceeding 25 for flame-spread index. Smoke developed index ratings shall not exceed 50 when tested according to ASTM E84.

D. Air Flow Pressure Drop: Air flow pressure drop values shall not exceed those indicated on the Drawings. The air flow pressure drop performance shall be certified by the manufacturer to have been tested and rated in accordance with applicable portions of AMCA Bulletin 210, or with a method of air measurement approved by the Authority.

E. Source Quality Control:

1. Acoustic Performance: Test according to ASTM E477.

2. Record acoustic ratings, including dynamic insertion loss and self-noise power levels with an airflow of at least 2000-fpm face velocity.

3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

F. Manufacturers: Subject to compliance with requirements, provide sound traps from one of the following (or approved equal):

Industrial Acoustics Company
Koppers Co., Inc.
Aeroacoustic Corp.
Vibro-Acoustics
VAW Systems Inc.
Price Industries
McGill AirFlow Corporation.
Dynasonics, A PCI Industries Company

PART 3 - EXECUTION

3.1 INSPECTION

A. Contractor shall examine location where ductwork is to be installed and determine space conditions and notify Architect in writing of conditions detrimental to proper and timely completion of the work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF DUCTWORK

A. Install ductwork in accordance with recognized industry practices, to ensure that ductwork complies with requirements and serve intended purposes.

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

C. Duct sizes shown on the drawings at connection to fans or other equipment may vary in actual installation. Contractor shall provide transition pieces as required.

D. Ducts, casings and hangers shall be installed straight and level and shall be free of vibration and noise when fans are operating.

E. Ducts at ceilings shall be suspended from inserts in new concrete slabs only except where otherwise indicated. Ducts at floor shall be supported by steel angles suitably anchored to floor construction. Each duct shall be independently supported and shall not be hung from or supported by another duct, pipe, conduit or equipment of any trade. All supports shall be approved by the structural engineer.

F. Supports shall be placed at each joint and change in direction up to a maximum spacing of 8 feet on centers. Prevent buckling of ductwork.

G. All fastenings to building structure shall be adequate to insure permanent stability of sheet metal work and shall be capable of resisting all applied forces.

H. Vertical ducts in shafts or passing through floors shall be supported by steel angles or channels, welded, riveted, screwed or bolted to ducts and fastened to building structural members at each floor level. Provide safing to close all floor openings around ductwork pack annular space with rockwool and 18 gauge sheet metal safing Floor openings in plenums shall have 1/2 inch diameter steel bars.

I. Rigid connections between ductwork and non-rotating equipment shall be made with flanged joints, sealed with fireproof material (Fiber or Neoprene gaskets).

J. It is the intent to obtain low pressure ductwork construction with minimum leakage. The construction noted in Specifications can produce low or high leakage rates, depending upon the workmanship, particularly with regard to the connection at the top of the ducts. Guarantee that total diffuser volume, measured by means of velometer, shall be at least 95% of actual fan supply (measured by means of a duct traverse taken with a Pitot tube and water manometer). Seal the ductwork at joints with suitable sealers and tape.

K. For leakage test for medium and high pressure ductwork refer to Section "Testing and Balancing.

3.3 DUCT HANGERS

A. Medium pressure ductwork is hereby defined as ductwork subject to operating pressures in excess of 2” w.g., positive or negative. All ductwork regardless of pressure upstream of VAV terminal units shall be classified as medium pressure ducts

B. Low pressure ductwork is hereby defined as ductwork subjected to velocities of 2500 fpm or less, and operating pressure of 2" w.g. or less, positive or negative

C. Low pressure ducts (ductwork up to 24" on a side or up to 20" diameter shall be suspended with 16 gauge, galvanized strap hangers, 1" wide

D. Low pressure ducts 25" to 40" on a side or 21" to 40" diameter shall be suspended with galvanized strap hangers 1" wide by 1/8" thick.

E. Strap hangers shall be bent 90°, extended down sides of ducts and turned under bottom of ducts a minimum of 2". Strap hangers shall be fastened at slab with nuts, bolts and lock washers and to sides and bottom of ducts with sheet metal screws.

F. All medium pressure ductwork and low pressure ducts 41" and larger on a side or diameter shall be suspended with eighter rod or angle type hangers. No screws shall penetrate medium and high pressure ductwork.

G. Rod type hangers shall be 3/8" diameter black steel rods threaded at both ends and bottom bracing angles on ducts, with nuts and lock washers.

H. Angle type hangers shall be extensions of side bracing angles on ducts, bent 90° at ceiling and fastened with nuts, bolts and lock washers.

I. Hangers for vertical ducts shall be as per SMACNA Duct Manual.

J. Stainless steel ductwork shall be supported with rod or angle type hangers, so that there will be no penetration of the stainless steel ducts.

3.4 CONNECTIONS

A. Contractor shall arrange to have the connections of metal ductwork to equipment and shall provide flexible connection for each ductwork connection to equipment mounted on vibration isolators, and/or equipment containing rotating machinery.

B. Coordinate as necessary to ensure that access doors have been provided in hung ceilings and any other required places for proper operation and maintenance

3.5 CLEANING AND PROTECTION

A. Clean ductwork internally, unit by unit as it is installed of dust and debris. Clean external surfaces of foreign substances, which might cause corrosion, deterioration of metal or interfere with painting.

B. At end of ducts which are not connected to equipment or air distribution devices at the time of ductwork installation, provide temporary closure of polyethylene film or other covering.

C. After the completion of ductwork installation clean ductwork as follows:

1. Cover all supply registers and diffusers with oil cheese cloth.
2. Use supply fan to provide air to the system for four (4) hours.
3. Remove oil cheese cloth.

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SECTION 23 34 40

FANS AND VENTILATORS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. This Section is to coordinate with and be complementary to the General Conditions, General Requirements and Supplemental General Requirements, wherever applicable to Mechanical and Electrical Work.

B. Section 21 00 00 - Special Requirements for Mechanical and Electrical Work shall apply.

1.2 DESCRIPTION OF WORK

A. The work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete and made ready for operation by the Owner, all fans and ventilators as shown on the drawings and hereinafter specified.

1.3 QUALITY ASSURANCE

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

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

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

1.4 SUBMITTALS

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work and submit shop drawings.

1.5 COORDINATION

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work.

1.6 GUARANTEE

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work.

PART 2 - PRODUCTS

2.1 IN-LINE FANS

A. Furnish and install In-line Centrifugal Fans (direct or belt drive) of size and capacities as indicated on Drawings. Housing shall be constructed of heavy gauge, continuously welded steel to assure no air leakage. Inlet cones shall be bolted to the inlet side of the housing and shall be removable for access to the wheel. A removable drive cover allows access to bearings, shaft and pulleys.

B. Standard heavy-duty bearings are grease lubricated, self-aligning balls or roller type in pillow block mounts.

C. Flanged inlets and outlets with mounting holes shall be provided for ductwork connection.

D. Non-overloading airfoil wheels shall be constructed of heavy gauge steel continuously welded to the wheel cone and to a heavy gauge backplate.

E. Each fan wheel shall be statically and dynamically balanced.

F. Bolted access door shall be provided to access to the wheel for inspection or cleaning.

G. Air and sound shall be A.M.C.A. certified.

2.2 ROOF TYPE EXHAUST FANS

A. Roof type exhaust fans shall be of the power roof ventilator type complete with motor, frame, housing, and all other items and accessories. The fan wheel shall be aluminum. All other parts of the fan with which the air stream comes in contact shall be aluminum, stainless steel or reinforced fiber glass polyester plastic. The use of a heavy gage steel motor support plate protected with a baked enamel finish may be accepted.

B. Fan Unit

1. The fan shall be capable of exhausting the cubic feet of air per minute with the static pressure, minimum wheel diameter and speed shown on the Drawings. After assembly of motor and wheel, the rotating parts shall be statically and dynamically balanced at rated speed to provide vibration free operation.
2. The fan shall be quiet operating, backward curved centrifugal non-overload type, provided with approved type belt drive. Direct-connected fans shall be furnished only when indicated on the Drawings. Fan drives shall be sized in accordance with the manufacturer's recommendations. Belts shall be selected for at least 50% excess motor horsepower. Motor shall have an adjustable pitch driving sheave and shall be separated from the air stream. The motor shall be of size and characteristics noted on the Drawings with a terminal box. Wheel and motor support assembly shall be of heavy gage aluminum, galvanized steel, or steel which has been thoroughly coated with a corrosion resisting paint. Fan and motor

shall be supported on vibration isolation mounts. The fan shall be provided with an inlet ring or core.

3. The frame of the unit shall be made of aluminum or stainless steel of suitable thickness to insure structural integrity of the unit. The entire unit shall be designed to provide for easy removal of the fan, motor, and all other items and accessories without disturbing the balance of the unit.

C. Housing

The fan unit shall be provided with a closed weatherproof housing of one of the types indicated below. Hardware, screws, and all other items and accessories used in the construction of the fan housing shall be of stainless steel or non-ferrous material. Housing shall be provided with 1 brass or cadmium plated padlock where the hood is hinged, or 2 padlocks where the hood is removable. 3 master keys for all padlocks shall be furnished and delivered to the Owner. Housing shall be of such design as to form a uniform passage for air all around the rim. The air discharge openings shall be provided with wire mesh screens of 1/2" mesh, No. 16 gage copper, bronze, aluminum or PVC encapsulated bird guard with brass or aluminum screws. Screens shall be securely fastened in place with aluminum, brass or stainless-steel fasteners. Where the fan design includes an integral wiring conduit, it shall be large enough to permit passage of a 3/4" conduit through it. Where an integral wiring conduit is not included, openings for the passage of 3/4" conduit (for service wiring) from base of fan into motor compartment shall be provided by the fan manufacturer. Low silhouette type housings are not acceptable. Approved type housings are:

1. Spun Aluminum: This type housing shall be fabricated from not less than No. 14 gage aluminum in wheel sizes less than No. 30.
   a. The top cover for size No. 30 shall be not less than No. 14 gage and the skirt, support base and curb shall be not less than No. 12 gage.
   b. For size No. 36 fan, the cover, skirt and curb shall be not less than No. 12 gage, and the 'support base shall be not less than No. 10 gage.
   c. For size No. 48 fan, the cover shall be not less than No. 12 gage, skirt and curb shall be not less than No. 10 gage and the support base shall be not less than No. 8 gage.
   d. Die formed housings may be accepted, provided that gages of aluminum used are approved by the Owner.
   e. Factory coated. Color as selected by Architect.

2. Reinforced plastic: This type housing shall be dome-shaped, molded and bonded reinforced fiberglass polyester plastic. Sizes, less than No. 21 shall have the housing made from not less than 3/32" thick plastic. Fan size No. 21 and larger shall be of greater thickness but not less than 1/8".

D. Thermal Overload Protection

Provide starter with thermal overload protection and pilot light for each roof exhaust fan.

E. Disconnecting Switch

Each roof type exhauster with 2-horsepower or smaller motor shall be provided with a disconnecting switch in general purpose enclosure mounted inside of the housing near the motor. Wiring between motor and switch shall be installed by the fan manufacturer in 1/2" (minimum

size) Greenfield conduit. Disconnect switch shall be positioned in a location easily accessible for field connection of 3/4". Disconnect switches for single phase motors shall be 2pole, Arrow-Hart No. 6808; for three phase motors, they shall be 3-pole, Arrow-Hart No. 7810. Submit sample for other switches. Disconnect switches for roof type exhausters having larger than 2-horsepower motors will be provided within the fan housing by the Subcontractor for Electric Work.

F. Dampers
When shown on the Drawings, self-acting aluminum dampers, mounted on an aluminum angle frame shall be provided in the inlet to the fan. All parts of the self-acting dampers shall be constructed of non-ferrous metal. The use of nylon bearings may be accepted. Gravity type dampers up to 2000 cfm and electric motor operated dampers, above wired to the fan: Open when fan is energize and close when fan is de-energize.

G. Extension for Damper
Every roof exhauster shall have an extension base at least 12" high, except for fans serving as kitchen range hood or warming pantry exhausters. Each 12" extension base shall have an inspection opening with gasket and No. 14 gage aluminum cover plate in one side of the base. Extension bases for fans with motor operated dampers shall have a weather protected access panel, with handle, of ample size to permit removal of damper unit in one side of the extension. Extension base shall be fabricated from not less than No. 14 gage aluminum sheets and shapes and shall form a rigid structural member for the fan and housing mounted upon it. Extension shall fit the roof curb and shall be secured to it with stainless steel lag screws.

H. Bearings
Bearings shall be heavy duty self-aligning ball bearing type, either permanently lubricated or equipped with fittings for grease lubrication. In the latter case, a grease gun of the proper type shall be furnished and delivered to the Owner.

2.3 KITCHEN EXHAUST FAN

A. Roof exhaust shall be belt driven, upblast vertical discharge type. Construction of housing shall be heavy gage aluminum. The windband shall have a rolled bead and additional structural members for added strength. The fan and wheel inlet cone shall be aluminum and of the high performance, centrifugal blower type. Wheel shall be statically and dynamically balanced. Construction shall include built in grease drain. Provide a stainless-steel container to collect grease and drain off excess water. Container shall be mounted to avoid accidental tip over. Motors shall be of the heavy-duty type with permanently lubricated, sealed ball bearings. Air for cooling the motor shall be taken into the motor chamber by means of an air tube from a location free of discharge contaminants. The entire drive assembly and wheel, as a unit, shall be removable through the support structure without dismantling the fan housing. The wheel shaft shall be mounted in heavy duty ball bearings. Drives shall be sized for 165% of driven horsepower. Pulleys shall be adjustable cast iron type keyed to the fan and motor shafts. The entire drive assembly shall be mounted on rubber vibration isolators. Fans shall be AMCA approved for sound and air performance. Model shall be U.L. listed for commercial cooking applications and grease laden vapors. A vented curb extension shall be used to meet NFPA 96 requirements for 40" discharge height.

B. The roof type exhaust fan used with a kitchen range hood shall be equipped with means of isolating the motor compartment from the heat of the exhaust fumes.

2.4 PROPELLER FANS

A. The propeller fans shall have the capacities in the schedule on the Drawings. Provide OSHA protective screens for motor and fan.

B. Provide electrically operated dampers and motors. Damper motor voltage shall be 120 V. Provide transformer if fan motor is 208 V.

C. Belt driven, axial type sidewall fans shall provide as follows:

1. Propellers shall be constructed with fabricated steel or fabricated aluminum. Propellers shall be securely attached to fan shafts. All propellers shall be statically and dynamically balanced.
2. Motors shall be permanently lubricated, heavy duty type, carefully matched to the fan load and furnished at the specified voltage, phase, and enclosure.
3. Ground and polished steel fan shafts shall be mounted in permanently lubricated, sealed ball bearing pillow blocks. Bearings shall be selected for a minimum (L10) life in excess of 100,000 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 wheel and motor shafts. Motors sheaves shall be adjustable for system balancing.
4. Drive frame and panel assemblies shall be galvanized steel or painted steel. Drive frames shall be formed channels and fan panels shall have prepunched mounting holes, formed flanges, and a deep formed inlet venturi. Drive frames and panels shall be bolted construction or welded construction (level 3 fans only).
5. The axial exhaust fans shall be the AMCA Certified Ratings Seals for both sound and air performance.
6. Fans shall be Model SBE as manufactured by Greenheck or equal.

D. Direct drive, axial type sidewall fans shall be provided as follows:

1. Propellers shall be constructed with fabricated aluminum. A standard square key and set screw or tapered bushing shall lock the propeller to the motor shaft. All propellers shall be statically and dynamically balanced.
2. Motors shall be permanently lubricated, heavy duty type, carefully matched to the fan load and furnished at the specified RPM, voltage, phase, and enclosure.
3. Motor drive frame assemblies and fan panels shall be galvanized steel or painted steel. Drive frame assemblies shall be welded wire or formed channels and fan panels shall have prepunched mounting holes, formed flanges, and a deep formed inlet venturi.
4. The axial exhaust shall bear the AMCA Certified Ratings Seals for both sound and air performance.
5. Fans shall be Model SE1 as manufactured by Loren Cook or equal.

2.5 LAUNDRY EXHAUST SYSTEM

A. The box ventilator (BEF) shall be suitable for indoor and outdoor installation. The BEF shall have an insulated galvanized steel housing with a statically and dynamically balanced aluminum backwards curved centrifugal impeller. The BEF shall have a hinged door for easy cleaning and service. The BEF shall be designed to meet Type B, Spark Resistant Construction, and to exhaust lint-laden air from single or multiple Type I or Type II clothes dryers. The BEF shall be equipped with an air-cooled, maintenance-free variable speed permanent magnet motor with pre-lubricated and sealed bearings. The BEF's motor with MSC EDrive Motor Controller (EDrive) shall be rated at 92% efficiency and able to operate as low as 50 rpm. The motor shall be protected from overloading, blocking, over voltage, under voltage, and overheating. The motor shaft shall be internally isolated to eliminate the need for external shaft grounding. The motor shall be located outside the exhaust air stream to comply with the International Code Council's requirements for commercial dryer exhaust.

B. The modulating exhaust control shall be a true PID microprocessor-based control and shall be able to maintain a constant negative pressure with a tolerance of 0.01"W.C., by modulating the BEF's motor speed via the EDrive. The control shall include a pressure transducer, silicone tubing and a duct probe. The duct's pressure shall be referenced just downstream of the clothes dryers. For multistory applications, the duct's pressure shall be referenced in the lower portion of the exhaust riser while the building's pressure shall be referenced in the lower portion of the building. The control shall operate the BEF continuously. The control shall have a safety function to notify building management in case of insufficient pressure or ventilator failure, and indicate this with a visual alarm. The control shall have a display of the actual pressure.

C. Furnish a NEMA 4X-enclosed disconnect switch with a maximum rating of 25A and 600V for the box ventilator.

D. Contractor shall install structural, mechanical, electrical, and control connections as designed by the manufacturer and in accordance with the terms of the manufacturer's warranties.

E. Follow all pertinent national, state, and/or local codes where applicable.

2.6 PREFABRICATED ROOF CURBS

A. Furnish and install a roof curb for each roof exhaust fan, as indicated on the Drawings. The curbs shall be all aluminum curbs.

B. All roof curbs for roof exhaust fans shall have fiberglass linings.

C. All roof curbs shall be 12" high.

D. Roof curbs shall be of same manufacturer as roof fans.

E. Kitchen exhaust roof curb: provide extended subbase with hinging kit, grease cup with extended fitting.

F. Provide double shell roof curb for all roof mounted exhaust fans.

PART 3 - EXECUTION

3.1 INSPECTION

A. Contractor shall examine location where this equipment is to be installed and determine space conditions and notify architect in writing of conditions detrimental to proper and timely completion of the work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install equipment where shown, in accordance with manufacturer's written instructions, and with recognized industry practices, to ensure that equipment comply with requirements and serve intended purposes.

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

C. Check alignment and, where necessary (and possible), realign shafts or motors and equipment within tolerances recommended by manufacturer.

3.3 FIELD QUALITY CONTROL

A. Upon completion of installation of equipment, test equipment to demonstrate compliance with requirement. When possible, field correct malfunctioning units, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected. Refer to Section - Testing and Balancing.

END OF SECTION 23 34 40

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SECTION 23 57 19

PLATE-TYPE-LIQUID-TO-LIQUID HEAT EXCHANGERS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Provide plate heat exchangers as shown on the Drawings and as needed for a complete and proper installation; product specific requirements are contained herein.

1.2 RELATED WORK

A. Division 23 Sections

1.3 SUPPLEMENTAL SUBMITTALS

A. Product Data: Submit manufacturer's product data for plate heat exchangers including capacity, performance charts, test data, materials, dimensions, weights, and installation instructions. Plate type heat exchangers utilizing water shall be certified per AHRI 400 and Table 6.8.1H of ASHRAE 90.1-2010. Plate type heat exchangers utilizing fluids other than water (such as glycols) are not included in the AHRI certification program. For glycol heat exchangers, performance shall be verified by data furnished by the manufacturer (reference ASHRAE 90.1-2010 Article 6.4.1.4d).

B. Maintenance Data

1. Maintenance Manual

C. Provide a set of Manufacturer’s guarantees for the equipment provided.

D. Manufacturer's certified data report, Form No. U-1, for ASME unfired pressure vessels

E. Maintenance materials

F. Certificate: Contractor’s start-up and demonstration affidavit

G. Seismic shop drawings and design calculations: Signed/sealed by a qualified professional engineer indicating anchorages and attachments to structure and to supported equipment. Indicate requirements for selecting seismic restraints and for designing bases.

1.4 SUPPLEMENTAL QUALITY ASSURANCE

A. Code and Standards: Fabricate and label exchangers in accordance with ASME Boiler and Pressure Vessel Code for Unfired Pressure Vessels (Section VIII, “Pressure Vessels,” Division 1 and IX).

B. All equipment or components of this specification section shall meet or exceed the requirements and quality of the items herein specified, or as denoted on the drawings.

C. Ensure equipment pressure ratings are at least equal to the system’s maximum operating pressure at point where installed, but not less than specified.

D. Equipment manufacturer shall be a company specializing in manufacture, assembly, and field performance of provided equipment with a minimum of 5 years experience.

E. Equipment provider shall be responsible for providing certified equipment start-up and field certified training session. New equipment start-up shall be for the purpose of determining equipment operation.

F. The design, materials, manufacturing methods and factory- testing of the plate exchanger units shall be in strict conformance with all applicable sections of the ASME code, and shall bear the standard ASME symbol.

G. Per Section MC 1003.1, all pressure vessels shall bear the label of an approved agency and shall be installed in accordance with the manufacturer’s installation instructions. The requirements for unfired pressure vessels shall be the same as required for boilers designed for the same operating temperatures.

H. Per Section MC 1003.2, all piping materials, fittings, joints, connections, and devices associated with systems utilized in conjunction with pressure vessels shall be designed for the specific application and shall be approved.

I. Per Section MC 1003.3, welding on pressure vessels shall be performed by approved certified welders in compliance with nationally recognized standards, ASME Boiler Pressure Vessel Code Sections VIII and IX.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the site in such a manner as to protect the materials from shipping and handling damage. Provide materials on factory provide shipping skids and lifting lugs if required for handling. Materials that can be damaged by the elements should be packaged in such a manner that they could withstand short-term exposure to the elements during transportation.

B. Store materials in clean, dry place and protect from weather and construction traffic. Handle carefully to avoid damage.

1.6 SPARE PARTS

A. Provide one (1) set of gaskets for each plate heat exchanger.

1.7 WARRANTY

A. Provide a minimum of two (2) year warranty. All warrantees shall use the date of Substantial Completion as the start date.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide plate heat exchangers of the size and capacity indicated on the Drawings. Arrange frame to provide the number of channel stainless steel plates indicated. Provide plate heat exchangers complete with stainless steel saddles or mounting legs for securing the supports.

B. Heat exchanger shall meet types, sizes, capacities, and characteristics as scheduled on the Equipment Schedule drawings.

2.2 MATERIALS

A. Provide a plate and frame, water to water, type heat exchanger of the sizes and capacities noted on the Drawings Schedule. The heat exchanger shall consist of stainless steel heat transfer plates, steel end plates, and a stainless steel carrying bar, of single pass configuration. Unit's shall be specifically designed for 150 PSIG working pressure at 230ºF. Heat exchanger selection shall be optimized by the manufacturer to provide minimum heat transfer surface area requirements under specified capacity and pressure drops.

B. The plate heat exchanger shall be shipped to the site as completely assembled units. The heat exchanger shall be pressure tested and flushed clean at the factory prior to shipment. All nozzle connections shall be factory sealed prior to shipment to prevent the entrance of foreign matter into the heat exchanger during shipment, storage, and installation.

C. Corrugated channel steel plates shall be of type 316 Stainless Steel. Channel plate ports shall be double gasketed to prevent cross contamination of hot and cold side fluids. Gaskets shall be of a one piece design formulated from Nitrile rubber. Plates shall be grooved to accept the gaskets and gasket clips to minimize movement.

D. Channel carrying bar shall be stainless steel with zinc yellow chromate finish.

E. Flow through the plates shall be of a counter flow design to maximize the heat transfer capability of the unit.

F. Connections 2" and smaller shall be carbon steel NPT tappings. Connections 2½" and larger shall be studded port design to accept ANSI flange connection. Connection ports shall be integral to the frame or pressure plate.

G. Unit to be supplied with OSHA approved splash guard, enclosing exterior channel plate and gasketed surfaced. Heat exchanger shall be provided with the scheduled square footage of heat transfer area.

H. Unit shall be constructed in accordance with ASME Code Rules and shall have a manufacturer's data report for pressure vessels, form No. U-1. Form U-1 shall be furnished to the engineer for the owner. An authorized inspector, holding a National Board commission, certifying that construction conforms to the latest ASME Code for pressure vessels must sign this form. The ASME "U" symbol should also be stamped on the Heater Exchanger(s). In addition, each unit registered with the National Board of Boiler and Pressure Vessel Inspectors.

I. Heat exchanger manufacturer shall be ISO-9001 certified.

J. Insulation shall comply with ASHRAE 90.1-2010 and shall be suitable for the operating temperature. Surround entire heat exchanger except connections.

2.3 MANUFACTURERS

A. Manufacturer's data report for unfired pressure vessels, form No. U-1 as required by the provision of the ASME Code Rules, shall be furnished. This form shall be signed by a qualified inspector, holding a National Board Commission, certifying that construction conforms to the latest ASME Code for unfired pressure vessel.

B. Approved Manufacturers:
Bell & Gossett ITT; Fluid Handling Div.
Alfa Laval Thermal API Heat Transfer
Inc.
Armstrong Pumps Invensys
APV, Inc.
Mueller, Paul Company Polaris
Plate Heat Exchangers Tranter
PHE, Inc.

PART 3 – EXECUTION

3.1 INSTALLATION

A. All components shall be installed in accordance with manufacturer's installation instructions.

B. Proper access space around the exchangers shall be left for servicing the components. Provide no less than the minimum recommended by the manufacturer. Clearances shall be maintained around all components so as to permit inspection, servicing, repair, replacement and visibility of all gauges. When units are installed or replaced, clearance shall be provided to allow access for inspection, maintenance and repair. Passageways around all sides of the units shall have an unobstructed width as required by the manufacturer.

C. Proper component start-up practices and procedures shall be followed on all components as recommended by the manufacturer.

D. All piping shall be brought to equipment connections in such a manner so as to prevent the possibility of any loads or stresses being applied to the connections or piping. All piping shall be fitted to the plate heat exchangers even though piping adjustments may be required after the pipe is installed.

E. Water Piping: Provide piping including union, shutoff valve, pressure gauge, and thermometer on inlet; union, shutoff valve, relief valve, pressure gauge, and thermometer on outlet. Pipe relief valve outlet to drain.

3.2 INTERDISCIPLINARY TESTS AND FUNCTIONAL PERFORMANCE TESTS

A. The Contractor shall perform the manufacturer's interdisciplinary pre-start/start-up tests and functional performance tests and shall submit affidavit that all tests have been successfully completed. Contractor shall then demonstrate the equipment.

3.3 COMMISSIONING OF PLATE HEAT EXCHANGER

A. HVAC Contractor shall comply with the Commissioning Requirements of Contract Specifications for the plate heat exchangers. Systems that utilize plate heat exchangers (ex. packaged air-cooled chillers, cooling towers, etc.) must be commissioned along with the plate heat exchanger.

B. All associated chilled water and condenser water piping shall be tested prior to the commencement of the commissioning process.

3.4 TRAINING

A. The Custodian shall be trained on the operation and maintenance of the system. All training shall be a minimum of 4 hours.

END OF SECTION 23 57 19

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SECTION 23 74 33

DEDICATED OUTDOOR AIR UNITS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Provide packaged constant volume dedicated outside air system (DOAS) units as specified, as shown on the Drawing schedules and as needed for a complete and proper installation. Product specific requirements are contained herein.

B. Units shall be provided for the ventilation of the Bedrooms, Living Rooms, Corridors and other areas as shown on the Drawings.

C. All fans of the units shall be provided with variable frequency drives to facilitate the initial balancing procedure and for fan airflow control per the Sequence of Operation.

D. Units shall be provided with OEM controls.

1.2 RELATED SECTIONS

A. Section 23 05 48 – Vibration and Seismic Controls for HVAC

B. Section 23 07 00 – HVAC Insulation

C. Section 23 09 00 – Instrumentation and Controls for HVAC

D. Section 26 05 23 – Control-Voltage Electrical Power Cables

1.3 REFERENCES

(AHRI has introduced Standard 920 “Performance Rating of DX Dedicated Outdoor Air System Units”. Testing for rating is next step in implementation of this rating standard.) NFPA 90 A & B - Installation of Air Conditioning and Ventilation Systems and Installation of Warm Air Heating and Air Conditioning Systems. (all)

A. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration. (all)

B. ANSI/ASHRAE/IESNA 90.1-2010 - Energy Standard for New Buildings Except Low-Rise Residential Buildings.

C. ANSI Z21.47/UL1995 - Unitary Air Conditioning Standard for safety requirements.

D. California Energy Commission Administrative Code - Title 20/24 - Establishes the minimum efficiency requirements for HVAC equipment installed in new buildings in the State of California. (all)

E. ANSI/NFPA 70-1995 - National Electric Code. (all)

F. International Fuel Gas Code (g/e)

1.4 SUPPLEMENTAL SUBMITTALS

A. Product Data
1. Manufacturers Product Data
2. Installation Instructions
3. Performance Charts

B. Shop Drawings
1. Submit assembly-type shop drawings showing unit dimensions, weight loadings, required clearances, location, construction details, and mounting and field connection details.
2. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to air handling units by Electrical Contractor. Submit manufacturers wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed by the Temperature Control System Contractor (TCC).

C. Coordination Drawings: Submit with Shop Drawings. Show layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

D. Certifications
1. Include the certified fan-sound power ratings. Provide radiated, supply discharge and return inlet computer generated sound power levels.
2. Contractor’s start-up and demonstration affidavit.
3. Certification of operability for smoke control systems that are to remain operable following the design earthquake ground motion per Section 13.2.2 of ASCE 7-10.

E. Maintenance Materials: Filters and belts (when belt driven fans are provided in lieu of direct driven fans).

F. Maintenance Data
1. Maintenance Manual

G. Preventative Maintenance Plan and Schedule

H. Warranties specified in this Section.

I. All unit end devices including but not limited outside air intake dampers, recirculation dampers and heating/cooling valves (shipped loose if necessary) shall be factory tested by simulating their

hard-wired sensor input and observing/recording the proper operation of the end device. Supply fan and VFD shall be factory configured/programmed and tested. Submit all factory testing results.

J. The Original Equipment Manufacturer (OEM) shall furnish to the Owner a licensed fully-functional copy of the toolset (i.e. software program) necessary for communication with and the adjustment of their controller.

1.5 DELIVERY, STORAGE and HANDLING

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

B. Protect units from physical damage. Leave factory shipping covers in place until installation.

1.6 SUPPLEMENTAL QUALITY ASSURANCE

A. Codes and Standards
1. Packaged units shall comply with ASHRAE 90.1-2013.
2. A prototype unit shall be ETL listed and labeled, classified in accordance with UL 1995/CAN/CSA/ No. 236-M90.

B. Before submitting any equipment shop drawings for approval, the HVAC Contractor, Temperature Controls Contractor (TCC) and the Equipment Vendor and Manufacturer shall coordinate the controls required for the system.

C. Wiring internal to the unit shall be wired to a numbered terminal strip for simplified identification and ease of trouble shooting.

D. The manufacturer shall have a quality management system in place equal to the quality assurance standard ISO 9001, for the design, manufacture, and service of packaged ventilation/air conditioning equipment. Units that are field assembled from pre-fabricated panels shall not be considered or accepted.

E. Fan performance shall be based on tests and procedures performed in accordance with AMCA Publication 211 and Publication 311 and comply with the requirements of the AMCA Certified Ratings Program. Fans shall bear the AMCA seal.

F. Casing paint system shall comply with ASTM B117 2000-hour salt fog resistance test.

G. Fan motors shall be furnished with efficiencies equal to or greater than those specified in the Energy Policy Act of 1992 (EPACT) and ASHRAE 90.1-2013.

H. Required smoke dampers for 15,000 CFM and greater capacity shall be classified by Underwriters Laboratory as a leakage rated damper for use in smoke control systems under the

latest version (Rev. 4 or later) of UL555S and shall be minimum leakage Class II, rated for minimum 250ºF.

I. Filters shall comply with UL 900-1994.

1.7 WARRANTY

A. Provide parts warranty extending either 12-months from date of unit start-up or a maximum of 18-months from unit ship date.

B. Provide twenty-five year heat exchanger limited warranty from unit ship date.

C. OPTION: The manufacturer shall furnish an alternative price for:
1. Extended digital scroll compressor warranty for 5 years.
2. Extended heat exchanger warranty for 25 years on units 20 tons and above.
3. Extended parts and labor by manufacturer to be provided to the owner for a period of 5 years.

1.8 MAINTENANCE SERVICE

A. Furnish complete parts and labor service and maintenance of packaged outdoor air units for 1 year from Date of Substantial Completion by OEM.

B. Provide maintenance service with a two month interval as maximum time period between calls. Provide 24 hour emergency service on breakdowns and malfunctions.

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

D. Submit copy of service call work order or report and include description of work performed.

E. Must have twenty factory-certified and factory-trained technicians within a four-hour radius of the jobsite.

1.9 REGULATORY REQUIREMENTS

A. Unit shall conform to the appropriate standards listed in Section 103 as well as be listed and labeled by a Nationally Recognized Testing Laboratory (NRTL) for compliance with the following applicable standards.
1. Standard for Safety Heating and Cooling Equipment-Third Edition, UL 1995/CSA C22.2 236-05, dated February 18, 2005, with revisions through July 30, 2009 (all for cooling and for electric heat)
2. Standard for Gas Unit Heaters And Gas-Fired Duct Furnaces ANSI Z83.8-2006, CSA 2.62006, Third Edition – 2006 (indirect gas-fired/e)
3. Standard for Non-Recirculating Direct Gas-Fired Industrial Air Heaters, ANSI Z83.4/CSA 3.7 - 2003 with addenda ANSI Z83.4/CSA 3.7 - 2004a and addenda ANSI Z83.4/CSA 3.7 - 2006b (direct gas-fired/e)
4. In the event the unit is not approved by an NRTL for compliance with the appropriate standards, the manufacturer shall, at manufacturer’s expense, provide for a field certification and labeling of unit by an NRTL to the appropriate standards. Manufacturer

shall, at manufacturer's cost, complete any and all modifications required by NRTL prior to certification and field labeling. Manufacturer shall include coverage of all modifications in unit warranty.

1.10 EXTRA MATERIALS

A. Provide one set of filters.

PART 2 - PRODUCTS

2.1 SUMMARY

A. The contractor shall furnish and install packaged outdoor air unit(s) as shown and scheduled on the contract documents. The unit(s) shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

2.2 APPROVED MANUFACTURERS

A. Daikin: Rebel Packaged rooftop System

B. Trane: Horizon™ Model OAU (Packaged Outdoor Air Unit)

C. Addison: TRS-Series

D. LC-Systems: Commander

E. Substitutions: [submission for substitution is required a minimum of 10 working days prior to bid date] as indicated under the general and/or supplemental conditions of these specifications. Bidding contractor shall be responsible for electrical and mechanical and structural modifications required when substituting a product other than the specified product. It shall be the responsibility of the bidding contractor to make the specifier aware of any modifications. As built drawing changes are the responsibility of the contractor submitting the substitution.

2.3 GENERAL UNIT DESCRIPTION

A. Unit(s) furnished and installed shall be packaged outdoor air unit(s) as scheduled on contract documents and described in these specifications. Unit(s) shall be designed for dehumidification, cooling and/or heating of 100% Outdoor Air. For dehumidification and cooling modes the evaporator temperature shall be monitored, reported at unit controller. Compressor controls shall modulate capacity to maintain evaporator leaving set point. Hot Gas Bypass shall not be used to control compressor capacity. Compressor Hot Gas Reheat (HGRH) shall be factory installed. To prevent rehydration of evaporator condensate the reheat coil face shall be located a minimum of 6" downstream from the leaving face of the evaporator coil. Heating system shall include modulating controls. Compressor on-off only or heating on-off only controls shall not be acceptable control strategies.

B. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

C. Unit discharge airflow configuration shall be:

D. Horizontal discharge thru unit roof curb.

E. Wiring internal to the unit shall be colored and numbered for identification.

2.4 CABINET

A. Cabinet base shall be double wall construction designed to prevent trapping or ponding of water within the unit base. Top of cabinet base pan shall be insulated with 2” thick polyisocyanurate foam. Foam insulation shall be fully enclosed with galvanized steel insulation cover. Insulation shall not be applied to underside of unit base.

B. Cabinet Base Rails: Side and end base rails shall include openings for forklift and tie-down access. To protect unit base from fork damage side rails shall include removable heavy gauge fork pockets.

C. Shipping anchors attach to and/or through unit base rails. Straps over unit shall not be used to secure unit for shipping.

D. Cabinet material interior and base rails: shall be G-90 zinc-coated galvanized steel. Material gauge shall be a minimum of 14-gauge for base rails, 16-gauge for structural members and 20gauge for access doors and cabinet panels.

E. Exterior Corrosion Protection: Exterior cabinet panels shall be a base coat of G-60 galvanized steel with both exterior and interior surfaces cleaned, phosphatized and finished with a weatherresistant baked enamel finish. Unit’s surface shall be in compliance with ASTM B45 salt spray testing at a minimum of 672 hour duration.

F. Cabinet panels: 2” double-wall foamed panel construction throughout the indoor section of unit to provide nonporous, cleanable interior surfaces. All interior seams exposed to airflow shall be sealed.

G. Insulation: 2” polyisocyanurate Foam metal encapsulated with no exposed edges. Initial R value of 6.6 per inch of thickness.

H. Cabinet construction shall provide hinged panels providing easy access for all parts requiring routine service.

I. Cabinet top cover shall be one piece construction or where seams exist, it shall be double-hemmed and gasket-sealed.

J. Hinged Access Panels: Water- and air-tight hinged access panels shall provide access to all areas requiring routine service including air filters, heating section, electrical and control cabinet sections, ERV, power exhaust fan section, supply air fan section, evaporator and reheat coil sections. Door hardware shall be constructed to allow the door swing to be reversed in the field.

1. Hold-open devices shall be factory installed on all hinged access doors. Chains shall not be used as hold-open devices.
2. Latches with locking hasp or tool operated closure devices shall be factory installed on all hinged access panels.

K. Drain Pan material shall be Type 304 Stainless steel drain and constructed to be sloped in two directions to ensure positive drainage with corners exposed to standing water and drain fittings welded liquid tight to prevent leaks. Pan shall have a minimum depth of 2". Base of pan shall be insulated with 1" thick foam insulation.

L. Provide openings either on side of unit or thru the base for power, control and gas connections.

M. Cabinet shall include optional Interior liner constructed of Type 304 stainless steel with sealed seams.

N. Air inlet hood shall be factory installed and shall not require field assembly. Hood shall include 2" thick removable aluminum mesh mist eliminators sized for a velocity not to exceed 500 FPM at maximum unit rated airflow. Service access shall be hinged and held in place with thumb latches that shall not require tools for service access.

O. Unit shall be equipped with a 6" filter rack upstream of the evaporator. Frame shall be field adjustable to match any filter combination specified in the following section.

2.5 AIR FILTERS

A. Unit inlet hood shall include 2" thick aluminum mesh removable mist eliminators with hinged access cover. Inlet velocity shall not exceed 500 FPM.

B. Evaporator Inlet shall include a full compliment of pleated media air filters. Filters shall be:
1. 2" deep MERV 8
2. 2" deep MERV 13

2.6 DAMPERS

A. Unit shall include a motor operated outdoor air damper constructed of galvanized steel.
B. Damper blades shall be air foil design with rubber edge seals designed not to exceed a 4 CFM/SQ FT leakage rate exceeding ASHRAE 90.1 damper leakage requirements.
C. Damper linkage shall be located out of the airstream, and concealed within the damper frame to reduce air pressure and air noise.

D. Damper actuator shall be factory mounted and wired sealed spring return and either two-position or fully modulating.

E. Dampers air velocity shall not exceed 2000 fpm.

F. Return Air damper shall be of same material, construction and leakage rate as outdoor air damper. Return air damper actuator shall be factory mounted and wired sealed spring fully modulating and operate based on outdoor air damper feedback signal to properly regulate RA airflow.

2.7 DEHUMIDIFICATION/COOLING

A. Compressors
1. All units shall have direct-drive, hermetic, scroll type compressors with centrifugal type oil pumps.
2. Motor shall be suction gas-cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate voltage.
a. Internal overloads shall be provided with the scroll compressors.
b. Each compressor shall have a crankcase heater to minimize the amount of liquid refrigerant present in the oil sump during off cycles.
c. Each compressor shall be mounted on rubber vibration isolators, to reduce the transmission of noise.
d. Provide each unit with hermetically sealed refrigerant circuit(s) factory-supplied completely piped with liquid line filter-drier, liquid line charging port, suction and liquid line pressure ports, sight glass, and thermal expansion valve.
e. Provide each circuit with automatic reset high and low pressure switches for safety control.
3. Provide APR valve capacity control on lead circuit.

B. Coils

1. Evaporator, Condenser and Hot Gas Reheat coils shall be constructed with copper tubes mechanically bonded to configured aluminum plate fins.
2. Coils shall be factory leak tested in accordance ANSI/ASHRAE 15-1992 at a minimum pressure of 500 PSIG.
3. Evaporator coil shall include six rows of cooling interlaced for superior sensible and latent cooling with a maximum of 12 FPI for ease of cleaning.
4. Reheat coil shall be fully integrated into the supply airstream and be capable of delivering design supply air temperature.
5. To prevent re-hydration of condensate from evaporator coil, the evaporator coil face and the hot gas reheat coil face shall be separated by a minimum of six inches.

C. Condenser Section
1. Outdoor Fans: Shall be direct drive vertical discharge design with low-noise corrosion resistant glass reinforced polypropylene props, powder coated wire discharge guards and electro-plated motor mounting brackets.
2. Fans shall be statically and dynamically balanced.

2.8 HEATING

A. Modulating Indirect Gas Fired Heating System
1. Completely assembled and factory installed heating system shall be located in the primary heating position located beneath the indoor fan assembly and be integral to unit and approved for use downstream from refrigerant cooling coils in units mounted outdoors.

Threaded gas connection shall terminate at manual shut-off valve provided with unit. Provide capability for sidewall or thru-base gas piping connection.

2. Heaters shall include high turn-down burners firing into individual stainless steel tubular heat exchangers. Heat exchangers shall be constructed of type 439 stainless steel and be a high efficiency dimpled tubular design capable of draining internal condensate. External flue to be constructed of Type 304 stainless steel and be fully insulated. Units with multiple heaters shall include one fully modulating high turndown heater with additional on-off heater sections. Total heater turndown shall be based on heater gas input capacity 5:1 when ≤150 MBH or a minimum of 10:1 when >150 MBH.
3. Heater outdoor air inlet shall be hooded include internal baffle system to prevent rain blow thru. To prevent recirculation of flue gas and to prevent flue gas condensate from draining onto and obstructing the heater air inlet the inlet shall be hooded and shall be located a minimum of 11" beneath the flue outlet and shall not be located directly below the flue outlet. Inlet hood shall include bird screen.
4. Unit compartments including electrical and compressor shall be isolated and sealed from heater service compartment to prevent exposure to heater flue gases, excess heat and/or moisture.
5. Heater flue outlet(s) shall include hooded outlet with wire cloth all constructed of Type 304 stainless steel. Hooded outlet shall be sealed to prevent flue gas recirculation.
6. Gas Burner Safety Controls: Provide safety controls for the proving of combustion air prior to ignition, continuous air proving monitoring following ignition and continuous electronic flame supervision.
7. Timed freeze stat shall monitor heat output and shall discontinue all heating attempts and or unit operation in the event the heating section fails to ignite or fails to maintain programmed supply air temperature/time.
8. Inducer fan shall be direct drive high pressure centrifugal type with two speeds and shall include built- in thermal overload protection.
9. Limit controls: High temperature automatic reset limits shall be located on blower wall and in indoor fan chamber to shut off gas flow in the event of excessive temperatures resulting from restricted indoor airflow, or loss of indoor airflow.
10. Flame roll-out safeties shall provide continuous monitoring of proper burner operation.

2.9 ELECTRICAL RATINGS AND CONNECTIONS

A. All high voltage power components such as fuses, switches and contactors shall include a service personnel protection barrier or shall be a listed as touch-safe design.

B. Field wiring access to be provided thru unit base into isolated enclosure with removable cover.

C. Power wiring to be single point connection.

D. Unit shall be factory wired to field wiring terminal block mounted in isolated enclosure.

E. Factory wired main power disconnect and overcurrent device shall be rated for total unit connected power

F. Unit SCCR rating shall be a minimum of 5kA

G. Factory wired Phase monitor shall be included as standard.

H. Factory to mount and wire optional120 volt convenience outlet. Field wiring of convenience outlet not acceptable.

I. All low voltage field wiring connections shall be made at factory installed low voltage terminal strip.

2.10 UNIT CONTROLS

A. Main Unit Controller (MCM) shall be a microprocessor based controller with resident control logic. Controller program logic shall include single program with field selectable
   1. Discharge Air control with unit conditioning modes enabled based on outdoor air conditions and controlled to maintain discharge air setpoints.
   2. Space control with unit conditioning modes enabled and controlled to maintain space setpoints.

B. MCM shall:
   1. Prevent simultaneous operation of any conditioning modes.
   2. Accept separate setpoints for Occupied and Unoccupied states.
   3. Call for Dehumidification based on dew point setpoints. When no call for Dehumidification is present MCM shall control calls for Cooling, Heating and Economizer modes based on sensible temperature setpoints. MCM shall have onboard clock and scheduling function for occupancy.
   4. Include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.
   5. Enable HGRH dehumidification and cooling modes and control modulation to maintain (discharge air temperature / space temperature).
   6. Prevent low-ambient compressor operation via a user defined compressor lockout outdoor air temperature setpoint.
   7. Enable Supply Air Tempering function when the unit is in heating mode but not actively heating. Outdoor air heat set point will continue heat operation to maintain a minimum discharge air heating temperature setpoint and prevent heater cycling

C. MCM Touch Screen shall include full color display and shall be factory installed in unit control compartment and provide a full list of points included in the MCM. The display shall provide a list and history of all unit alarms.

D. System Sensors shall include: Factory installed and wired Outdoor Air Temperature, Outdoor Air Humidity and Evaporator Leaving Air Temperature and factory furnished field installed Discharge Air Temperature. (Factory shall furnish Space Temperature and Space Humidity sensor for field installation and connection to the unit). E. System controls shall include:
   1. Anti-cycle timing.
   2. Minimum compressor run/off-times.

F. Smoke Detectors to sense Return and Discharge Air streams shall be factory installed and wired.

2.11 ROOF CURB

A. Contractor shall provide factory supplied 48" tall roof curb as indicated in drawings. Ship knocked down and provided with instructions for easy assembly.

B. Curb shall be manufactured in accordance with the National Roofing Contractors Association guidelines.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Contractor shall verify that roof is ready to receive work.

B. Contractor shall verify that proper power supply adequate to supply the unit.

3.2 SUPPLEMENTAL INSTALLATION

A. Packaged Units
1. Electrical Wiring: The Electrical contractor shall provide power for the units. Furnish copy of manufacturer's wiring diagram submittal to Electrical.
   a. All wiring in the packaged unit sections shall be in standard (in accordance with the NYS Electrical Code) or flex type conduit. Wiring shall be color-coded and shall be numbered at termination points. Control circuit wiring shall be 16-gage minimum type TFF. Power wiring shall be minimum 12-gage type THHN wire. Wiring diagrams shall be laminated to inside of control panel door. The unit manufacturer shall provide control panel(s) that shall contain all necessary components for full control of the unit. These control panels shall be provided with 115 volts and 24 volts step down transformers.
   b. The unit manufacturer shall furnish, controllers with sufficient input and output (I/O) capability for system operation, monitoring and alarms. Interface relays shall be provided. Shop drawings shall illustrate complete unit interface wiring diagrams for the specific unit and testing procedures. Shop drawings shall indicate the Sequence of Operations.
   c. The unit manufacturer shall provide all safety controls to meet code requirements, a 24-volt control circuit, and mounting and wiring of all unit controls and devices. Unit manufacturer shall furnish terminal strip(s) to interface the OEM DDC Controller to the field mounted devices to be field wired by the Temperature Control Contractor (TCC).
2. Ductwork: Connect supply and return/exhaust ducts to unit with flexible duct connections. Provide transitions to exactly match unit duct connection size.

3. Drain Piping: Connect unit drain to nearest indirect waste connection if unit is inside of building and to splash block if unit is roof mounted. Provide trap at drain pan; construct at least 1" deeper than fan pressure in inches of water.

3.3 FIELD QUALITY CONTROL

A. Start-up packaged units in accordance with manufacturer's start-up instructions and in the presence of a manufacturer's representative. The OEM and Temperature Control Contractor shall test the OEM DDC system and communication cards and demonstrate compliance with requirements of the Specifications and Drawings to the satisfaction of the Owner's Facility Management Systems Integrator or Owner's Representative. Replace all damaged and malfunctioning controls and equipment. The Contractor shall perform necessary Interdisciplinary Tests and Functional Performance Tests.

3.4 INTERDISCIPLINARY TESTS AND FUNCTIONAL PERFORMANCE TESTS

A. Interdisciplinary Pre-Start-Up and Start-Up Tests

The Contractor shall conduct interdisciplinary pre-start up and start up tests as per the manufacturer's start up procedures. Contractor shall submit signed start up affidavit signed by the factory authorized service representative indicating that all of the manufacturer's pre-start up and start up procedures have been successfully completed.

B. Functional Performance Tests

Contractor shall also submit signed functional performance testing affidavit signed by the factory authorized service representative indicating that all of the manufacturer's functional performance tests have been successfully completed. Refer to the functional performance tests as defined in Section 15970 since a BMS/DDC system is to be provided and the equipment is to be integrated into the BMS/DDC system.

END OF SECTION 23 74 33

SECTION 23 81 26

SPLIT SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. This Section is to coordinate with and be complementary to the General Conditions, General Requirements and Supplemental General Requirements, wherever applicable to Mechanical and Electrical Work.

B. Section 21 00 00 - Special Requirements for Mechanical and Electrical Work shall apply.

1.2 DESCRIPTION OF WORK

A. The work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, air cooled split A/C units as indicated and scheduled on the Drawings and as hereinafter specified.

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

1.3 QUALITY ASSURANCE

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

B. Unit performance shall be certified in accordance with the latest editions of ARI Standards 210 and 270.

C. The refrigerant coil shall be designed and tested in accordance with ANSI B9.1 Safety Code for Mechanical Refrigeration.

D. Unit shall be constructed in accordance with UL regulations and shall carry the UL label of approval.

E. Coil leak testing shall be at 350 psig air pressure with the coil submerged in water. After testing, the coils shall be dehydrated and charged with dry air.

1.4 SUPPLEMENTAL SUBMITTALS

A. Product Data: Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics; and start-up instructions.

B. Wiring Diagram: Diagram power and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Maintenance Data
1. Maintenance Manual

D. Maintenance Materials
1. Spare Filters

E. Certificate: Contractor's start-up and demonstration affidavit.

F. Manufacturer's Warranties.

1.5 COORDINATION

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work.

1.6 MAINTENANCE MATERIALS

A. Provide two (2) complete set of spare filters for each evaporator unit.

1.7 GUARANTEE

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work.

B. Warranty: Include a 5 year warranty for refrigeration compressors, including material and delivery.

1.8 DELIVERY, STORAGE AND HANDLING

A. Unit shall be stored and handled in accordance with the unit manufacturer's instruction.

PART 2 - PRODUCTS

2.1 SINGLE EVAPORATOR DUCTLESS SPLIT HEAT PUMP SYSTEM

A. Manufacturer:
Indoor Unit: Daikin or approved equal.
Outdoor Unit: Daikin or approved equal.

B. Provide an air-to-air electric heat pump (outdoor unit) in combination with a direct expansion fan-coil heat pump (indoor unit) in the location shown on the Drawings. The units shall be designed and tested for use with Refrigerant R-410A and be equipped with refrigerant line fittings which permit mechanical or sweat connection. The electrical requirements, the size, the cooling and heating capacities shall be as indicated on the Drawings.

C. Unit shall be factory assembled, piped, and internally wired. Units shall be UL listed and carry a UL label. Unit shall be factory run-tested to check cooling and heating operation, defrost

operation, fan and blower rotation and control sequence. Unit shall be designed to operate at ambient temperature between 115°F and 55°F in cooling mode (as shipped) and between 75°F and -20°F in heating mode.

D. Coil shall be constructed with aluminum plate fins mechanically bonded to copper tubing with all joints brazed.

E. The outdoor unit shall contain a semi-hermetic compressor with crankcase heater, automatically reversible oil pump, internal and external motor protection. Outdoor fan shall be propeller type, with vertical discharge and direct driven by a factory-lubricated motor. Refrigerant circuit access ports located outdoors shall be fitted with locking-type tamper-resistant caps requiring a special tool or key to open.

F. Indoor unit shall operate properly on horizontal position (with or without) ductwork. Unit shall have electric resistance heaters as specified for back-up of heat pump heating capacity) and shall contain refrigerant metering device and indoor fan relay. Fan shall be centrifugal type, belt driven.

G. Controls and protective devices shall include a high pressurestat, loss-of-charge pressurestat, crankcase heater, suction line accumulator and pressure relief device. Motor compressor shall have both thermal and current sensitive overload devices. The outdoor unit shall provide short cycle protection or safety lockout compressor protection.

H. Defrost control shall sense need to defrost every 90 minutes based on liquid temperature. On system using multiple units, a defrost interlock control shall be provided. A 24-volt transformer shall be factory installed and wired on outdoor units for external control circuit.

I. System accessories shall include indoor thermostat, outdoor thermostat, head pressure control, heat pump piping package, return air grille, filters, electric resistant heaters, discharge air grille and plenum, suspension package, indoor coil defrost thermostat, sub-base, fan and drives, outdoor fan cycling thermostat, emergency heat control package, compressor short cycle protection and sequencer control.

J. Each unit shall have the cooling and heating capacity, phase, voltage and amperage shown on the Drawings. Provide a metal name plate securely attached to the side of the unit (outdoor and indoor), readily visible. The name plate shall have inscribed on it, the following information in clear and legible lettering, manufacturer's name, Model No., month and year of installation, BTUH Rating, voltage and current rating for each unit.

K. The maximum radiated outdoor unit sound power levels shall be as follows:

Center Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Band Designation	1	2	3	4	5	6	7	8
Db								

PART 3 - EXECUTION

3.1 SUPPLEMENTAL INSTALLATION

A. Install outdoor unit with mounting legs supplied by the manufacturer, on prefabricated roof equipment curbs provided by the contractor, with all the clearances required as shown on the Drawings.

B. Install the indoor unit with the suspension package tied to the overhead construction as shown on the Drawings.

C. Install the wall mounted unit as close as possible to the ceiling clear of any obstruction in front of unit by at least 5’0”.

D. For ceiling hung and wall hung units, Mechanical Contractor shall provide a [primary pan overflow drain line] [auxiliary drain pan and associated drain line] as shown on the Drawings for each cooling or evaporator coil to avoid damage to any building component as a result of overflow from the primary equipment drain pan or stoppage in the primary condensate drain piping. One of the following methods shall be used:
   1. Mechanical Contractor shall coordinate with sheet metal subcontractor to provide an auxiliary drain pan as shown on the Drawings with a separate drain under the coils on which condensation will occur. The auxiliary pan drain shall discharge to a conspicuous point of disposal (as shown on the Drawings) to alert occupants in the event of a stoppage of the primary drain. The auxiliary pan shall have a minimum depth of 1.5”, shall not be less than 3” larger than the unit or the coil dimensions in width and length and shall be constructed of corrosion-resistant material. Auxiliary metallic pans shall have a minimum thickness of not less than 0.0236” (No. 24 gage) for galvanized sheet metal pans, 0.0179” (No. 26 gage) for stainless steel pans, or 0.0320” (No. 20 gage) for aluminum pans. Nonmetallic pans shall have a minimum thickness of not less than 0.0625”
      or
   2. Mechanical Contractor shall provide a separate overflow drain line connected to the primary drain pan provided with the equipment. Such overflow drain shall discharge to a conspicuous point of disposal (as shown on the Drawings) to alert occupants in the event of a stoppage of the primary drain. The overflow drain line shall connect to the primary drain pan at a higher level than the primary drain connection or
   3. Alternate Acceptable Installation: Mechanical Contractor shall coordinate with sheet metal subcontractor to provide an auxiliary drain pan without a separate drain line under the coils on which condensate will occur. Mechanical Contractor shall coordinate with the Temperature Controls subcontractor to provide a hard-wired water-level detection device for the auxiliary pan that will shut off the equipment served prior to overflow of the auxiliary pan. The auxiliary pan shall have a minimum depth of 1.5”, shall not be less than 3” larger than the unit or the coil dimensions in width and length and shall be constructed of corrosion-resistant material. Auxiliary metallic pans shall have a minimum thickness of not less than 0.0236” (No. 24 gage) for galvanized sheet metal pans, 0.0179” (No. 26 gage) for stainless steel pans, or 0.0320” (No. 20 gage) for aluminum pans. Nonmetallic pans shall have a minimum thickness of not less than 0.0625”
      or
   4. Alternate Acceptable Installation: On down-flow units and all other coils that do not have

a secondary drain or provisions to install a secondary or auxiliary drain pan, a water-level monitoring device shall be installed by the Mechanical Contractor or Temperature Controls Contractor inside the primary drain pan. This device shall shut off the equipment served in the event that the primary drain becomes restricted. Devices installed in the drain line shall not be permitted.

E. Install all other accessories as required by the manufacturers and indicated on the Drawings.

F. Clearances shall be maintained around all components so as to permit inspection, servicing, repair, replacement and visibility of all appurtenances. When units are installed or replaced, clearance shall be provided to allow access for inspection, maintenance and repair. Passageways around all sides of the units shall have an unobstructed width as required by the manufacturer.

G. Rigid or flexible metal enclosures or pipe ducts shall only be provided for soft annealed copper tubing used for refrigerant piping erected on the premises and containing other than Group A1 refrigerants.

3.2 FIELD QUALITY CONTROL

A. Upon completion of installation of the heat pump unit, start-up and operate equipment to demonstrate capability and compliance with requirements in the presence of the Manufacturer's Representative and the Owner. Field correct malfunctioning units, then retest to demonstrate compliance. Install new filters at completion of heat pump unit work, and prior to testing, adjusting, and balancing work. Obtain receipt from Contractor that new filters have been installed. Provide written Start-Up and Demonstration Affidavit certifying that the equipment is operating as designed. The contractor shall perform necessary Interdisciplinary Tests and Functional Performance Tests according to manufacturer’s procedures.

3.3 INTERDISCIPLINARY TESTS AND FUNCTIONAL PERFORMANCE TESTS

A. Interdisciplinary Pre-Start-Up and Start-Up Tests:

The Contractor shall conduct interdisciplinary pre-start up and start up tests as per the manufacturer’s start up procedures. Contractor shall submit signed start up affidavit signed by the factory authorized service representative indicating that all of the manufacturer’s pre-start up and start up procedures have been successfully completed.

B. Functional Performance Tests:

Contractor shall also submit signed functional performance testing affidavit signed by the factory authorized service representative indicating that all of the manufacturer’s functional performance tests have been successfully completed.

3.4 SIGNS, NAMEPLATES AND OPERATION AND EMERGENCY SHUTDOWN INSTRUCTIONS

A. Signs, nameplates, and operation and emergency shutdown instructions for refrigeration systems shall comply with the following:

1. Sections 9.15, 11.2.1, 11.2.2 and 11.7 of ASHRAE 15-10 as identified below.
2. Each refrigeration unit or system shall be provided with a nameplate indicating the "rated" horsepower of the prime mover or compressor and the equivalent of such horsepower in kilowatts.
3. Emergency signs shall comply with the following:

a. Refrigeration units or systems having a refrigerant circuit containing more than 220 pounds of Group A1 or 30 pounds of any other group refrigerant shall be provided with approved emergency signs, charts, and labels in accordance with NFPA 704.

B. Per ASHRAE 15-10 Section 9.15: Nameplate: Each unit system and each separate condensing unit, compressor, or compressor unit sold for field assembly in a refrigerating system shall carry a nameplate marked with the manufacturer's name, nationally registered trademark or trade name, identification number, the design pressures, and the refrigerant for which it is designed by the refrigerant number (R number as shown in Table 1 or Table 2 of ASHRAE 34-10).

C. Per ASHRAE 15-10 Section 11.2.1:
11.2.1 Installation Identification: Each refrigerating system erected on the premises shall be provided with a legible permanent sign, securely attached and easily accessible, indicating (a) the name and address of the installer, (b) the refrigerant number and amount of refrigerant, (c) the lubricant identity and amount, and (d) the field test pressure applied.

D. Per ASHRAE 15-10 Section 11.2.2:
11.2.2 Controls and Piping Identification: Systems containing more than 110 lb (50 kg) of refrigerant shall be provided with durable signs having letters not less than 0.5 in. in height designating: (a) valves or switches for controlling the refrigerant flow, the ventilation, and the refrigeration compressor(s), and (b) the kind of refrigerant or secondary coolant contained in exposed piping outside the machinery room. Valves or piping adjacent to valves shall be identified in accordance with ANSI A13.1, Scheme for Identification of Piping Systems.

E. Per ASHRAE 15-10 Section 11.7:
11.7 Responsibility for Operation and Emergency Shutdown: For a refrigerating system containing more than 55 lb (25 kg) of refrigerant, provide a schematic drawing or panel giving directions for the operation of the system at a location that is convenient to the operators of the equipment. Emergency shutdown procedures, including precautions to be observed in case of a breakdown or leak, shall be displayed on a conspicuous card located as near as possible to the refrigerant compressor. These precautions shall address (a) instructions for shutting down the system in case of emergency; (b) the name, address, and day and night telephone numbers for obtaining service; and (c) the names, addresses, and telephone numbers of all corporate, local, state, and federal agencies to be contacted as required in the event of a reportable incident.

END OF SECTION 23 81 26

SECTION 23 82 19 - FAN COIL UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fan Coils
   1. Direct-Driven Air Handling Units - 0.8 square feet to 3.2 square feet of coil face area.

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Section 23 09 00 – Instrumentation and Controls for HVAC

B. Section 26 05 23 – Control-Voltage Electrical Power Cables

1.3 RELATED SECTIONS

A. Section 23 20 10 – HVAC Piping

B. Section 23 05 10 – HVAC Specialties

C. Section 23 09 00 – Instrumentation and Controls for HVAC

D. Section 26 05 23 – Control-Voltage Electrical Power Cables

1.4 REFERENCES

A. ANSI/NFPA 70 - National Electrical Code.

B. NFPA 90 A & B - Installation of Air Conditioning and Ventilation Systems and Installation of Warm Air Heating and Air Conditioning Systems.

C. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

D. AHRI 350- Standard for Sound Rating of Non-Ducted Indoor Air-Conditioning Equipment.

E. ANSI S12.32 - Precision methods for the determination of sound power levels of discrete frequency and narrow-band noise sources in reverberation rooms.

F. ASHRAE Standard 62-89R - Ventilation for acceptable indoor air quality.

G. UL 181 - Factory Made Air Ducts and Connectors.

1.5 QUALITY ASSURANCE

A. Unit capacities certified under Industry Room Fan Coil Air Conditioning certification in accordance with AHRI Standard 440.

B. Unit designed and tested in compliance with AHRI 260.

1.6 SUBMITTALS

A. Submit unit performance data including: capacity, nominal operating performance and electrical consumption.

B. Submit Mechanical Specifications for unit and accessories describing construction, components and options.

C. Submit shop drawings indicating overall dimensions as well as installation, operation and service clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.

D. Submit data on electrical requirements. Include safety and start-up instructions.

1.7 REGULATORY REQUIREMENTS

A. Units must be UL listed as a Fan-Coil Unit and meet UL 883 - Fan-Coil Units Standard for Safety requirements, and UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

B. In the event the unit is not UL/CUL or ETL approved, the contractor shall, at his expense provide for a field inspection by a UL/CUL representative to verify conformance. If necessary, contractor shall perform modifications to the unit to comply with UL/CUL or ETL as directed by the representative, at no additional expense to the Owner.

C. Manufacturers must participate in the AHRI Certification program. Unit performance data must be rated in accordance with AHRI Standard 440, and must display the AHRI Symbol on all standard units. If a manufacturer does not participate in the AHRI Certification program, specified equipment must be witnessed by the engineer to meet the criteria of the specification. D. Conform to UL1995 for internal wiring of factory-wired equipment.

1.8 DELIVERY, STORAGE, AND HANDLING

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

B. Units shall ship fully assembled.

C. Store in a clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

D. Deliver units to site with factory mounted piping package. If piping package is not factory installed, contractor shall be responsible for all expenses associated with installation, and leak testing the assembly.

1.9 START-UP AND OPERATING REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters in place, condensate properly trapped, piping connections verified and leak-tested, all shipping braces removed, and fan has been test run under observation.

B. Include manufacturers' descriptive literature, operating instructions, installation instructions, maintenance and repair data, including filter replacement.

1.05 SUPPLEMENTAL QUALITY ASSURANCE

A. Codes and Standards:

1. ARI Compliance: Test and rate fan coil units in accordance with ARI Standard 440: Room Fan Coil Air Conditioners and ARI 840.
2. UL Compliance: Construct and install fan coil units in compliance with UL 883: Safety Standards for Fan Coil Units and Room Fan Heater Units. All electrical components shall be UL listed and label.
3. AMCA: All fans shall be AMCA certified.
4. NEMA: All electrical devices shall conform to NEMA Standards.
5. All wiring shall conform to 2005 NEC Standards as amended by the NYS Electrical Code.

B. When delivering the required amount of air, each fan coil unit shall operate such that the room noise levels specified in Section 15501 are complied with.

C. Before submitting any equipment shop drawings for approval, the HVAC Contractor, Automatic Temperature Controls Contractor and the Equipment Vendor and Manufacturer shall coordinate the controls required for the system.

1.10 WARRANTY

A. The equipment purchaser shall be provided, at no additional cost, a standard parts warranty that covers a period of one year from unit start-up or 18 months from shipment, whichever occurs first. This warrants that all products are free from defects in material and workmanship and have capacities and ratings set forth in the equipment manufacturer's catalog and bulletins.

B. Provide labor warranty for one year.

PART 2 – PRODUCTS

2.1 SUMMARY

A. The contractor shall furnish and install units as shown and scheduled in the plans. The units shall be installed in accordance with this specification and produce the specified performance in accordance with AHRI Standard 550/590-98.

B. Base bid shall be Daikin. Alternates must comply with the performance and features called for in this specification. Job awarded on basis of specified unit. Alternates will be considered after the job is awarded.

C. Manufacturer must clearly define any exceptions made to Plans and Specifications. Any deviations in layout or arrangement shall be submitted to engineer prior to bid date for approval. Mechanical Contractor is responsible for expenses that occur due to exceptions made.

2.2 GENERAL UNIT DESCRIPTION

A. Coils

1. Evenly spaced aluminum fins mechanically bonded to 3/8 inch OD minimum copper tubes, designed for 300 psi and 200 degrees F.
2. Units shall be provided with separate heating and cooling hydronic coils.

B. Drain Pan:

1. Drain pan(s) shall be constructed of corrosion resistant material. Acceptable materials include polymer or stainless steel.
2. Drain pan shall be sloped in two planes, pitched toward drain connection to ensure complete condensate drainage when unit is installed level.
3. Drain pan shall be insulated with closed-cell insulation. Spray foam insulation inside the drain pan is not acceptable.
4. Drain pan shall be easily removable for cleaning and for inspections per ASHRAE 6289R, without disconnecting piping, wiring or unit removal. Contractor shall be responsible for any unit modifications to ensure easy removal for cleaning and inspection, without cost to the owner.

C. Chassis and Cabinet:

1. Concealed: construction shall be minimum 18 gauge for framing, top panels, and side panels with all rounded edges on exposed corners.
2. Vertical Cabinet: construction shall be minimum 16 gauge for the front panel and 18 gauge for framing, top panels, and side panels with all rounded edges on exposed corners.
3. Recessed / Horizontal Cabinet: construction shall be minimum 18 gauge for the front/top/bottom panels, side panels and framing with all rounded edges on exposed corners.
4. Discharge Arrangements:
   a. Vertical concealed units shall have front toe space inlet and top duct collar outlet.
   b. Vertical cabinet units shall have front toe space inlet **OR** front bar grille inlet and top quad grille outlet **OR** top bar grille outlet.

c. Horizontal concealed units shall have bottom toe space inlet **OR** back duct collar inlet and front duct collar outlet.
d. Horizontal cabinet units shall have bottom stamped louver inlet **OR** back duct collar inlet **OR** back stamped louver inlet and front duct collar outlet **OR** front bar grille outlet **OR** front quad grille outlet.
e. Horizontal recessed units shall have bottom stamped louver inlet **OR** back duct collar inlet and front duct collar outlet.
f. Vertical recessed units shall have front stamped louver inlet and front stamped louver outlet **OR** top duct collar outlet.
g. Vertical slope top cabinet units shall have front toe space inlet **OR** front bar grille inlet and top quad grille outlet **OR** top bar grille outlet.
h. Compact concealed cabinet units shall have bottom stamped louver inlet **OR** back duct collar inlet **OR** bottom filter and front duct collar outlet.

5. Vertical cabinet units shall have leveling feet.
6. Cabinet and recessed units shall have a minimum of 14-inches available for the piping end pocket of the unit.
7. Cabinet and recessed units shall key-operated locking access doors.
8. Vertical cabinet units shall have 2” to 7” sub-bases sub-bases constructed of 18 gauge steel and painted the same finish as the base of the unit.
9. Vertical cabinet units shall have a 2” to 8” false back constructed of minimum 18 gauge steel and painted the same finish as the unit.
10. Cabinet units shall have a recessing flange constructed of 18 gauge steel and painted the same finish as the unit.
11. Vertical semi-recessed units shall have a 5/8” **OR** 2” thru 6” projection panel constructed of 16 gauge steel.

D. Cabinet Insulation:

1. Acceptable cabinet insulation shall include:
   a. Closed cell insulation or foil-faced insulation shall be the only acceptable material for insulating in accordance with ASHRAE 62-89R. Matted or fiber-glass insulation of any type is not acceptable.
   b. Insulation shall meet UL rating 94-5v for fire hazard classification which satisfies flame and smoke safety requirements.
   c. The exposed side shall be high density erosion proof material suitable for use in airstreams up to 4500 FPM.

E. Finish: Factory applied baked powder coat on visible surfaces of cabinet. Non-lead based paint must be used. To maintain a better long term appearance all bases, top control doors and grilles shall be black.

F. Fans: Centrifugal forward-curved double-width, double-inlet corrosion resistant wheels, statically and dynamically balanced, direct driven. Fans shall be constructed of metal with metal housing for long-term high reliability and shall be in the blow through configuration.

G. Motor: All motors shall be Brushless DC (BLDC)/Electronically Commutated Motors (ECM) factory programmed and run tested in assembled units.

1. The motor controller shall be mounted in a touch-safe control box with a built in integrated user interface and LED tachometer.
2. If adjustments are needed, changes to the motor parameters shall be made through the use of momentary contact switches accessible on the motor control board and adjustable without the need for factory service personnel.
3. Motors shall have a soft ramp between speed changes to minimize the acoustical impact due to speed changes.
4. Motors shall be operated at three speeds or with a field supplied variable speed controller. The motor will choose the highest will choose the highest speed, if there are simultaneous/conflicting speed requests.
5. All motors shall have integral thermal overload protection with a maximum ambient operating temperature of 104F and shall be permanently lubricated.
6. Motors shall be capable of starting at 50 percent of rated voltage and operated at 90 percent of rated voltage on all speed settings.
7. Motors shall operate up to 10 percent over-voltage.

H. Fan Speed Control: wall mounted or unit mounted fan speed controller will provide an interface to factory wiring, including variable speed/High-Medium-Low (HML) control. The control box will contain a line voltage to 24-volt transformer and ECM motor controller.
1. A unit mounted fan speed switch will be factory wired and electrically tested.
2. The fan speed switch shall open a factory-installed outside air damper when a fan speed is selected, and close the outside damper when the fan speed switch is in the OFF position.

I. Valve cycling control: The fan shall run continuously at the selected speed setting and the control valve shall cycle automatically to satisfy setpoint temperature setting. The unit controls shall be controlled by 24 volt relays and a factory-wired transformer.

J. Controller Interface: An interface shall be provided to interface to a third party controller.
1. The control box contains:
   a. Relay board
   b. Line voltage to 24-volt transformer
   c. Quiet contactors (for electric heat)
2. All end devices shall be wired to a low voltage terminal block and run tested.
3. When normally open valves are selected, inverting relays shall be provided for use with standard thermostats.

K. DDC Control: The Application Specific Controller (ASC) shall allow the control valve and 3-speed fan to work cooperatively to meet precise capacity requirements, while minimizing fan speed and valve position. The ASC shall be computer commissioned and tested before shipping from the unit factory. *The controller shall be compatible with the Honeywell ComfortPoint Open building automation system*. The application specific controller shall be factory mounted by the unit manufacturer and shall meet the following "Standard - Open" BACnet Protocol:
1. Unit Mounted Controller Standard Interoperability
   a. Unit Fan Coil Controllers shall reside on the BACnet network, and provide data using BACnet standard network variable types and configuration properties.
   b. Unit Fan-Coil Controllers shall support the BACnet Space Comfort Controller functional profile. The terminal unit controller supplier shall provide a list confirming their support for all mandatory data, and identify which optional network variables and configuration properties they support. Any vendor defined

network variables or configuration properties shall be described via an XIF file supplied with the product.

L. Entering Water Temperature Purge: For 2-pipe changeover applications using 2-way control valves; a control function will open the hydronic valve for three minutes to allow the entering water temperature to stabilize, then measures the entering water temperature to see if the preferred water temperature is available. If the preferred water temperature is not available, the hydronic valve closes and waits 60 minutes before attempting the sampling function again.

M. Piping Packages: Provide complete factory-assembled, installed and leak tested under water at 300 psig piping package. Bleed lines or ports will not be accepted. If piping package is shipped loose, the contractor is responsible for installing, and leak testing the piping package, without any additional cost to the owner.

N. *Provide a wired zone temperature sensing system with a built-in occupancy sensor*. The wired system shall work with any controller that accepts a 10k thermistor temperature input.
1. The receiver shall be factory mounted on the equipment.
2. The ambient operating temperature range for the RF transmitter shall be 32F to 122F (0C to 50C). The ambient operating temperature range for the RF receiver shall be 40F to 158F (-40C to 70C). The ambient storage temperature range for the RF transmitter and RF receiver shall be -40F to 185F (-40C to 85F). The ambient operating and storage humidity range shall be 5% to 95% non-condensing.
3. Zone temperature sensing accuracy shall be +/- 0.5F (+/- 0.28C)
4. Temperature sensing and transmission shall occur at least one each 30 seconds under conditions of rapid space temperature change or if the sensor is programmed with a fixed transmission period. Maximum time between transmissions shall be 15 minutes.

O. Filter: Easily removable 1-inch filter, located before the coil.

P. Tamperproof Locks: Fan coil units shall be provided with key operated locks on control access door. Filter section shall be removable without front panel removal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work and opening dimensions are as specified.

B. Verify that required utilities are available, in proper location, and ready for use.

C. Beginning of installation means installer accepts existing surfaces.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install fan coil units as indicated. Coordinate to assure correct recess size for recessed units.

C. Protect units with protective covers during balance of construction.

D. Contractor is responsible for providing hydronic units with shut-off valve on supply and lock shield balancing valve on return piping, as well as float operated automatic air vents with stop valve.

E. The following devices shall be shipped loose for field installation; unit space thermostat with built in occupancy sensor. All other devices including but not limited to the control valves shall be furnished and installed at the factory.

F. Furnish copy of manufacturer's wiring diagram submittal. Verify that electrical wiring installation is in accordance with manufacturer's submittals and installation requirements of Division 16 sections.

3.3 CLEANING

A. Clean work.

B. After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

C. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials available from manufacturer.

D. Contractor shall clean the coil and remove, clean, and reinstall the drain pan prior to turnover of the project. A signed certificate or inspection by facility engineer is required prior to final contract payment is made.

E. Install new filters.

3.04 INTERDISCIPLINARY TESTS AND FUNCTIONAL PERFORMANCE TESTS

A. Interdisciplinary Pre-Start-Up and Start-Up Tests:

The Contractor shall conduct interdisciplinary pre-start up and start up tests as per the manufacturer’s start up procedures. Contractor shall submit signed start up affidavit signed by the factory authorized service representative indicating that all of the manufacturer’s pre-start up and start up procedures have been successfully completed.

B. Functional Performance Tests:

Contractor shall also submit signed functional performance testing affidavit signed by the factory authorized service representative indicating that all of the manufacturer’s functional performance tests have been successfully completed.

END OF SECTION 23 82 19

SECTION 23 82 39

UNIT HEATERS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. This Section is to coordinate with and be complementary to the General Conditions, General Requirements and Supplemental General Requirements, wherever applicable to Mechanical and Electrical Work.

B. Section 21 00 00 - Special Requirements for Mechanical and Electrical Work shall apply.

1.2 DESCRIPTION OF WORK

A. The work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete and made ready for operation by the Owner, all unit heaters as shown on the drawings and hereinafter specified.

1.3 QUALITY ASSURANCE

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

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

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

1.4 SUBMITTALS

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work and submit shop drawings.

1.5 COORDINATION

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work.

1.6 GUARANTEE

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work.

PART 2 - PRODUCTS

2.1 UNIT HEATERS (STEAM/HOT WATER)

A. Provide horizontal and/or vertical throw unit heaters of types, capacities, speeds, and all other items and accessories as specified, scheduled and at the location(s) shown on the Drawings. Each

unit heater shall be complete with propeller fan, motor, steam or hot water heating coil, casing, and all other items and accessories. Unit heaters shall each be securely supported by overhead floor beams or by auxiliary steel beams installed for this purpose.

1. Heating Coils: The heating coil in each heater shall be constructed of copper tubes expanded into aluminum plate type fins. Units having two-row coils shall have the tube rows staggered to provide maximum heat output. Heating elements shall be tested with air at a minimum pressure of 300 psi under water. Design coil for use in steam or hot water applications.
2. Fan and Motor: Fan shall be propeller type with aluminum blades, well balanced to operate quietly at rated output. Fans for horizontal discharge shall each be equipped with a wire guard. Motors shall be single speed, designed for continuous operation and shall have the characteristics tabulated on the Drawings. Motor and fan assembly shall be so mounted as to prevent vibration transmission to the casing. Motor shall be equipped with a terminal base for conduit connection. Overload protection for unit heater motor will be provided in the starter.
3. Casing: Casing shall be constructed of furniture steel and shall be given a phosphatizing treatment to increase the bonding of the paint and to prevent corrosion. Finish paint shall consist of baked enamel in an approved color.
    a. Louvers: Each horizontal throw unit heater shall be equipped with adjustable double deflecting discharge louvers, capable of being locked in position after setting. Louvers shall be curved, and die-formed from heavy gauge steel.
    b. Diffusers: Each vertical throw unit heater shall be equipped with the type of diffuser or vaned outlet as indicated on the Drawings.
4. Controls: Each unit heater fan shall be controlled by an operating space low voltage BACnet thermostat or an operating space sensor/BACnet controller furnished and installed by the TCC (Temperature Control System Contractor). Reverse-acting limit controller shall be furnished and installed by the Temperature Control System Contractor on the hot water or condensate return piping immediately after the trap. The limit controller shall act to prevent the operation of the fan unless hot water or steam is being supplied to the coil of the unit. Both thermostatic controls shall be wired to operate on 24 volts AC.

2.2 UNIT HEATERS (ELECTRIC – For Freeze Protection)

A. Provide electric unit heater(s) as specified and scheduled and at the location(s) shown on the Drawings. Each unit heater shall consist of an electric heating element, fan, motor, controls, and all other items and accessories, factory assembled in a sheet steel casing. Casing shall receive a bonderized rust-preventive coating and a finished coat of baked enamel. Controls, provided by the unit manufacturer, shall consist of an automatic temperature controlling sensor (0-10VDC or 4-20mA or RTD or thermister) located at the air intake to the heating element and a fan delay switch that will prevent the fan from starting until the heating element is warm. Integral sensor shall be capable of field adjustment and shall be set initially at 50^{o} F (no unoccupied setback will occur for units located in crawl spaces or other unoccupied spaces that have pipes subject to possible freezing. Unit heaters for freeze protection located in mechanical rooms shall have occupied/unoccupied setpoint adjustments). Temperature Control Contractor (TCC) shall provide remote BACnet controller in the field that shall use the integral sensor hard-wired signal as input to the BACnet controller. The TCC shall also connect the communications network wiring to the TCC provided field BACnet controller. Alternate option is for the TCC to provide field BACnet thermostat in lieu of sensor/BACnet controller. Each unit heater shall be suspended by a bracket secured to an overhead floor beam or to an auxiliary steel beam installed for this

purpose. Contractor's P.E. shall detail required seismic restraints and submit seismic calculations. Electric unit heaters shall carry the UL or ETL label and shall operate at the voltages and phases as specified on the Drawings. The Division 16 Electrical Contractor shall provide service wiring to each unit heater.

The Temperature Control Contractor shall provide integration of monitoring and alarm functions by providing DDC control points as indicated in the Sequence of Operations – Section 15985 and on the control diagrams.

PART 3 - EXECUTION

3.1 INSPECTION

A. Contractor shall examine location where this equipment is to be installed and determine space conditions and notify architect in writing of conditions detrimental to proper and timely completion of the work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install the Work of this section in accordance with the manufacturer's printed installation instructions, unless otherwise specified.

B. Coordinate with other trades to assure correct recess size for recessed cabinet and unit heaters. Install all required access doors.

C. Steam/Hydronic Heaters shall be installed complete with hot water, steam and return piping, valve, trap, and all other items and accessories as shown on the Drawings.

D. The Electrical Contractor shall install electrical devices (line voltage electric thermostats, remote mounted speed switches) furnished by the unit manufacturer but not specified to be factory-mounted and specified. The Electrical Contractor shall verify that electrical wiring installation is in accordance with manufacturer's submittal. Do not proceed with equipment start-up until wiring installation is acceptable.

E. The Temperature Control Contractor shall furnish and install field control devices (thermostats, temperature sensors, BACnet controllers and BACnet thermostats).

F. The Temperature Control Contractor shall verify that the control wiring installation is in accordance with manufacturer's. Do not proceed with equipment start-up until control wiring installation is acceptable.

G. When a sensor/BACnet controller is provided in lieu of a BACnet thermostat, the BACnet controller shall be field installed by the Temperature Controls Contractor (TCC) either above the suspended ceiling or high on the wall (above sensor elevation).

3.3 PAINTING

A. Finish painting the cabinet and unit heaters after installation.

3.4 ADJUSTING AND CLEANING

A. After construction is completed, including painting, clean unit exposed surfaces, vacuum inside the unit and cabinet heaters. Retouch any marred or scratched surfaces, using finish materials furnished by the manufacturer.

3.5 INTERDISCIPLINARY TESTS AND FUNCTIONAL PERFORMANCE TESTS

A. Interdisciplinary Pre-Start-Up and Start-Up Tests:

The Contractor shall conduct interdisciplinary pre-start up and start up tests as per the manufacturer's start up procedures. Contractor shall submit signed start up affidavit signed by the factory authorized service representative indicating that all of the manufacturer's pre-start up and start up procedures have been successfully completed.

B. Functional Performance Tests:

Contractor shall also submit signed functional performance testing affidavit signed by the factory authorized service representative indicating that all of the manufacturer's functional performance tests have been successfully completed.

3.6 FIELD QUALITY CONTROL

A. Upon completion of installation of equipment, energized with normal power source, test equipment to demonstrate compliance with requirements. When possible, field correct malfunctioning units, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected.

END OF SECTION 23 82 39

SECTION 23 82 40

CABINET HEATERS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. This Section is to coordinate with and be complementary to the General Conditions, General Requirements and Supplemental General Requirements, wherever applicable to Mechanical and Electrical Work.

B. Section 21 00 00 - Special Requirements for Mechanical and Electrical Work shall apply.

1.2 DESCRIPTION OF WORK

A. The work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete and made ready for operation by the Owner, all cabinet heaters as shown on the drawings and hereinafter specified.

1.3 QUALITY ASSURANCE

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

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

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

1.4 SUBMITTALS

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work and submit shop drawings.

1.5 COORDINATION

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work.

1.6 GUARANTEE

A. Refer to Section 21 00 00 - Special Requirements for Mechanical and Electrical Work.

PART 2 - PRODUCTS

2.1 CABINET HEATER (Hot Water)

A. Provide single speed recessed cabinet heater(s) as specified, scheduled and at the location(s) shown on the Drawings. Heater shall have a steel enclosure front of not lighter than No. 14 gage, with integral inlet and outlet grilles. Front panel shall overlap wall opening on all sides and shall have gasket at the edges. Panel fasteners shall be of the spring-loaded type, or other approved, with Allen head. Entire cabinet shall be protected with rust inhibitive paint and finished with baked enamel, applied after bonderizing. Color of front shall be as selected by the Owner. Heater blower motor shall be controlled by means of an electric thermostat. Insulate interior surfaces of panels with acoustic 1/2" glass board that is covered with neoprene matte facing, which is sealed with any acrylic coating. Sealed fiberglass shall meet NFPA 90A requirements as well as UL181 erosion resistance requirements and ASTM G21, G22, and C1338 fungi/bacterial growth resistance.

The General Contractor shall furnish a steel frame, of proper size for each recessed cabinet heater, similar in construction to the frame shown in the Drawings. The frame shall be installed in the partitions, furring, and in all other items and accessories as shown on the Drawings. Frame shall be given a shop coat of a heat resistant primer. Where required, cutouts shall be made in the bottom of the frame to allow for piping connections. The recessed cabinet heater shall be secured to this frame.

1. Heating Coils: Coil shall be seamless copper tubing with mechanically bonded aluminum fins, designed for 150 psig working pressure for hot water and steam applications, and factory tested at 250 psig air pressure under water.
2. Cabinet heater shall be complete with proper size heating elements, two or more fans with housing, motor, motor control, and all other items and accessories, all factory assembled. Fans shall be mounted on a heavy gauge steel assembly board, and shall be directly driven. Thermal overload protection for the motor shall be provided. Built-in filter frame shall be mounted at the air inlet with disposable air filters.
3. Control circuit transformer and motor starter shall be provided by the unit manufacturer. The Temperature Control Contractor (TCC) shall provide limit controller (aquastat that monitors return hydronic water temperature or condensate return temperature). TCC shall provide 24-volt BACnet electric space thermostat or space sensor/remote BACnet controller. Space thermostats shall be installed approximately 7' above the floor for IS/HS Schools (5’-6” for Primary Schools) at the location shown on the Drawings and shall be equipped with locking covers and metal protective guards. BACnet thermostat shall enable the OEM provided blower operation. The unit manufacturer shall provide a control circuit transformer installed within the cabinet heater to provide a 24-volt circuit for the thermostat/controller. The limit controller shall be installed after the trap on the return piping from the steam coil or on the return piping of the hot water coils. The limit controller shall act to prevent the operation of the blower motor unless there is steam or hot water in the coil. The motor starter shall be installed within the other control devices as specified herein.
4. The Electrical Contractor shall provide service wiring to the starter. Control wiring to the space thermostats and to the limit controllers shall be provided by the Temperature Control Contractor. Wiring between the starter and the blower motor shall be provided by the cabinet heater manufacturer.

5. Accessories: Provide aluminum wall boxes with integral eliminators and insect screen. Provide access door as required.
For network connected cabinet unit heaters, the Temperature Control Contractor shall provide integration of monitoring and alarm functions by providing network control points as indicated in the Sequence of Operations.

PART 3 - EXECUTION

3.1 INSPECTION

A. Contractor shall examine location where this equipment is to be installed and determine space conditions and notify architect in writing of conditions detrimental to proper and timely completion of the work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install the Work of this section in accordance with the manufacturer's printed installation instructions, unless otherwise specified.

B. Coordinate with other trades to assure correct recess size for recessed cabinet and unit heaters. Install all required access doors.

C. Steam/Hydronic Heaters shall be installed complete with hot water, steam and return piping, valve, trap, and all other items and accessories as shown on the Drawings.

D. The Electrical Contractor shall install electrical devices (line voltage electric thermostats, remote mounted speed switches) furnished by the unit manufacturer but not specified to be factory-mounted and specified. The Electrical Contractor shall verify that electrical wiring installation is in accordance with manufacturer's submittal. Do not proceed with equipment start-up until wiring installation is acceptable.

E. The Temperature Control Contractor shall furnish and install field control devices (thermostats, temperature sensors, BACnet controllers and BACnet thermostats).

F. The Temperature Control Contractor shall verify that the control wiring installation is in accordance with manufacturer's. Do not proceed with equipment start-up until control wiring installation is acceptable.

G. When a sensor/BACnet controller is provided in lieu of a BACnet thermostat, the BACnet controller shall be field installed by the Temperature Controls Contractor (TCC) either above the suspended ceiling or high on the wall (above sensor elevation).

3.3 PAINTING

A. Finish painting the cabinet and unit heaters after installation.

3.4 ADJUSTING AND CLEANING

A. After construction is completed, including painting, clean unit exposed surfaces, vacuum inside the unit and cabinet heaters. Retouch any marred or scratched surfaces, using finish materials furnished by the manufacturer.

3.5 INTERDISCIPLINARY TESTS AND FUNCTIONAL PERFORMANCE TESTS

A. Interdisciplinary Pre-Start-Up and Start-Up Tests:

The Contractor shall conduct interdisciplinary pre-start up and start up tests as per the manufacturer's start up procedures. Contractor shall submit signed start up affidavit signed by the factory authorized service representative indicating that all of the manufacturer's pre-start up and start up procedures have been successfully completed.

B. Functional Performance Tests:

Contractor shall also submit signed functional performance testing affidavit signed by the factory authorized service representative indicating that all of the manufacturer's functional performance tests have been successfully completed.

3.6 FIELD QUALITY CONTROL

A. Upon completion of installation of equipment, energized with normal power source, test equipment to demonstrate compliance with requirements. When possible, field correct malfunctioning units, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected. Refer to Section - Test and Balancing.

END OF SECTION 23 82 40