SECTION 23 05 00
MECHANICAL GENERAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. Under this Section, the Contractor shall furnish all labor, materials and equipment for Mechanical General Requirements, as shown on the Plans, as specified and/or directed.

B. Related Work specified elsewhere:
   1. Division 1, “General Requirements”
   2. Division 22, “Plumbing”
   3. Division 23, “Mechanical”
   4. Division 26, “Electrical”

1.02 REFERENCE STANDARDS

A. The following is a list of standards that may be referenced in this section:
   1. Code of Federal Regulations (CFR) Publications:
      a. 29-1910 SUBPART O - Machinery and Machine Guarding
      b. 29-1910.219 - Mechanical Power Transmission Apparatus

1.03 SUBMITTALS

1.04 SUBMITTALS:

A. Submit shop drawings, manufacturer's data, publication compliance, certified test reports, and manufacturer's certificates of compliance for equipment, materials and finish, and pertinent details for each system where specified in each individual section, and have them approved before procurement, fabrication or delivery of the items to the job site. Shop drawings shall be accompanied by a letter of transmittal in duplicate, and all shop drawings shall be suitably identified with the name of the project, contract number, Contractor's name, date and initials indicating approval of such submittal by the Contractor under the applicable specification. Partial submittals will not be acceptable and will be returned without review. Submittals shall include the manufacturer's name, trade name, catalog model or number, nameplate data, size, layout dimensions, capacity, project specification and the specific technical paragraph reference which specifies each item, applicable industry and technical society publication references, and other information necessary to establish contract compliance of each item to be furnished.
   1. Manufacturer's Data: Submittals for each manufactured item shall be current manufacturer's descriptive literature of cataloged products, equipment drawings, diagrams, performance and characteristic curves, and catalog cuts.
   2. Shop Drawings: Drawings shall be a minimum of 8.5 inches by 11 inches in size, except as specified otherwise. Drawings shall include floor plans, sectional views, wiring diagrams, and installation details of equipment;

and equipment spaces identifying and indicating proposed location, layout and arrangement of items of equipment, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals, and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

3. Manufacturer's Certificates of Compliance: Submit certification from manufacturer attesting that materials and equipment to be furnished for this project comply with the requirements of this specification and of the reference publications. Pre-printed certifications will not be acceptable; certifications shall be the manufacturer's original; certifications shall be not more than one year old. The certification shall not contain statements that could be interpreted to imply that the product does not meet all requirements specified, such as "as good as"; "achieve the same end use and results as materials formulated in accordance with the referenced publications"; "equal or exceed the service and performance of the specified material". The certification shall simply state that the product conforms to the requirements specified. Certificates shall be signed by the manufacturer's official authorized to sign certificates of compliance.
4. Reference Standards Compliance: Where equipment or materials are specified to conform to industry and technical society reference standards of organizations such as the American National Standards Institute (ANSI), American Society for Testing and Materials (ASTM), National Electrical Manufacturers Association (NEMA), American Society of Mechanical Engineers (ASME), American Gas Association (AGA), American Refrigeration Institute (ARI), and Underwriters' Laboratories (UL), proof of such conformance shall be submitted. If an organization uses a label or listing to indicate compliance with a particular reference standard, the label or listing will be acceptable evidence, unless otherwise specified in the individual sections.

B. Independent Testing Organization Certificate: In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing and approved by the Engineer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.05 OPERATION AND MAINTENANCE MANUAL

A. Furnish an operation and maintenance manual for each item of equipment. Furnish three copies of the manual bound in hardback binders or an approved equivalent. Furnish one complete manual to the Owner's Representative for review and approval not more than 90 calendar days after an item is approved, but at least 60 calendar days prior to field acceptance testing of the item. Furnish the remaining manuals at least 60 days prior to contract completion. Inscribe the following identification on the cover: the words "OPERATION AND MAINTENANCE MANUAL", the name and location of the equipment or the

building, the name of the Contractor, and the contract number. The manual shall include the names, addresses, and telephone numbers of each subcontractor installing equipment, and of the local representatives for each item of equipment. The manual shall have a table of contents and be assembled to conform to the table of contents with the tab sheets placed before instructions covering the subject. The instructions shall be legible and easily read, with large sheets of drawings folded in. The manual shall include: wiring and control diagrams with data to explain detailed operation and control of each item of equipment; a control sequence describing start up, operation and shut down; description of the function of each principal item of equipment; the procedure for starting; the procedure for operating; shut down instructions; installation instructions; maintenance instructions; lubrication schedule including type, grade, temperature range, and frequency; safety precautions, diagrams, and illustrations; test procedures; performance data; and parts list. The parts lists for equipment shall indicate the sources of supply, recommended spare parts, and the service organization which is reasonably convenient to the project site. The manual shall be complete in all respects for equipment, controls, accessories, and associated appurtenances provided.

1.01 CATALOGED PRODUCTS

A. Materials and equipment shall be cataloged products of manufacturers regularly engaged in production of such materials or equipment and shall be manufacturer's latest design that complies with the specification requirements. Materials and equipment shall duplicate items that have been in satisfactory commercial or industrial use. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the items need not be the products of the same manufacturer. Each item of equipment shall have the manufacturer's name, address, model number and serial number on the nameplate securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.02 MANUFACTURER'S RECOMMENDATIONS

A. Unless otherwise stated in the Contract Specifications, all new equipment items, and specialties shall be installed in strict accordance with the recommendations of the manufacturer of the items being installed. Prior to the installation of new items, the Contractor shall submit to the Owner's representative printed copies of the manufacturer's installation recommendations. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material. Failure to install items in accordance with manufacturer's recommendations can be cause for rejection of the work items installed.

1.03 LAYOUT OF THE WORK

A. Coordinate the proper relation of the work to the building structure, existing utilities and to the work of all trades. The Contractor shall advise the Owner's Representative of any discrepancy before performing any work.
   1. Contract Drawings: The Contract Drawings represent the general intent as to piping and equipment arrangements. All locations and dimensions

shown shall be field verified and minor alterations made if so required. Where dimensions are not given for the location and arrangement of mechanical systems, locations may be assumed to be approximate, and may be altered if required. Major modifications to the indicated arrangements shall be approved by the Owner's Representative prior to the installation of mechanical systems. Schematic diagrams represent the overall system requirements and do not necessarily indicate the physical orientation, location or dimensions of that system.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Properly store, adequately protect, and carefully handle equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Engineer. Replace damaged or defective items.

1.05 SAFETY REQUIREMENTS

A. Equipment Safety: Fully enclose or properly guard in accordance with 29 CFR 1910.219 belts, pulleys, chains, gears, couplings, projecting setscrews, keys, rotating parts, and other power transmission apparatus, located where persons can come in close proximity thereto. Points of operation, ingoing nip points, and machinery producing flying chips and sparks shall be guarded in accordance with the applicable portions of 29 CFR 1910 SUBPART O. Provide positive means of locking out equipment so that equipment cannot be accidentally started during maintenance procedures. High temperature equipment and piping so located as to endanger personnel or create a fire hazard shall be properly guarded or covered with insulation of the type specified. Provide catwalks, maintenance platforms, and guardrails where required for safe operation and maintenance of equipment. Provide ladders or stairways to reach catwalks and maintenance platforms. Ensure that access openings leading to equipment are large enough to carry through routine maintenance items such as filters and tools.

1.06 ELECTRICAL REQUIREMENTS

A. Furnish motors, controllers, disconnects and contactors with their respective pieces of equipment. Motors, controllers, disconnects and contactors shall conform to and have electrical connections provided under Division 26-Electrical. Furnish internal wiring for components of packaged equipment as an integral part of the equipment. Extended voltage range motors will not be permitted. Controllers and contactors shall have a maximum of 120 volt control circuits, and shall have auxiliary contacts for use with the controls furnished. When motors and equipment furnished are larger than sizes indicated, the cost of additional electrical service and related work shall be included under this Section. Power wiring and conduit for field installed equipment shall be provided under and conform to the requirements of Division 26 - Electrical. Unless specifically noted otherwise, all control wiring (120 volt or less) shall be provided by Mechanical Contractor and conform to the requirements of Division 26 - Electrical.

1.07 INSTRUCTION TO OWNER'S PERSONNEL

A. When specified in other sections, furnish the services of competent instructors to give full instruction to the designated Owner's personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work. Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Owner for regular operation. The number of days (8 hours per day) of instruction furnished shall be as specified in the individual section. When more than 4 days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with the equipment or system. When significant changes or modifications in the equipment or system are made under the terms of the Contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

1.08 INSPECTIONS AND CERTIFICATIONS

A. The Contractor shall provide and pay for any third party inspections or certifications required by applicable regulatory agencies for boilers and other mechanical equipment components modified, or furnished and installed as a part of the Contract work.

1.09 SPECIAL CONDITIONS

A. The Contractor shall be performing work within active Museum and office areas and shall be responsible to coordinate with the Owner regarding planned interruptions to mechanical and electrical services.

1. Protection of Existing Work: The Contractor shall take all necessary precautions to insure against damage to existing work to remain in place, or to be reused. The Contractor shall insure that structural elements are not overloaded and additional structural supports required as a result of any cutting, removal or demolition work performed under any part of this Contract are added. The Contractor shall minimize disruption of existing non-contract work areas as much as possible.
2. Upon damage to existing equipment, buildings and/or structures, the Contractor shall immediately notify the Owner. All damages shall be repaired by the Contractor, or shall be replaced if beyond repair to match the existing to the Owner's satisfaction.
3. Protection of Buildings from the Weather: The interior of the buildings and all materials and equipment shall be protected from the weather at all times.
4. Protection of Personnel: Where the safety of non-contractor personnel is endangered in the area of the work, barricades shall be used. Additional protection shall be provided, if required, to preserve the safety of non-contractor personnel in the immediate area of the work.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.01 FIELD PAINTING

A. Conform to Section 09 91 23 – Interior Painting

END OF SECTION

SECTION 23 05 53
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Under this Section, the Contractor shall furnish all labor, materials and equipment for identification of HVAC piping and equipment including all pumps, fans, VAV boxes, ductwork, piping and valves using color bands, lettering, flow direction arrows, and related permanent identification devices for Identification for HVAC Piping and Equipment, as shown on the Plans, as specified and/or directed.

B. Related Work specified elsewhere:
   1. Section 23 05 00 – Mechanical General Requirements

1.02 REFERENCE STANDARDS

A. The following is a list of standards that may be referenced in this section:
   1. American National Standards Institute, Inc. (ANSI) Publication:
      a. A13.1 – Scheme for the Identification of Piping Systems
      b. Z535.1 – Safety Color Code

1.03 SUBMITTALS

A. Manufacturer's Data:
   1. Label, Tag and Nameplate materials
   2. List of wording, symbols, letter size, and color coding to be used
   3. Valve chart
   4. Accessory materials

PART 2 - PRODUCTS

2.01 MATERIALS

A. Pipe labels, valve tags and equipment nameplates shall be as manufactured by Marking Services Incorporated, or approved equal.
   1. NAMEPLATES: Three-ply laminated phenolic plastic at least 1/16" thick with black surfaces and white core. Engraving shall be minimum ½" high with appropriate spacing. Text shall be white on black background. Nomenclature shall match the equipment designation as indicated on the Plans and Schedules.
   2. VALVE TAGS: Three-ply laminated phenolic plastic at least 1/16" thick with black surfaces and white core. Engraving shall be minimum ½" high with appropriate spacing. Text shall be white on black background. Valve tag shall be minimum 1-1/2" diameter with smooth edges.
   3. PIPE MARKERS: Color, text and size shall conform to ASME/ANSI Standard A13.1.

a. Plastic Pipe Markers: Strap-type labels shall be factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering with flow direction arrows and identification of fluid being conveyed. Straps shall be self-locking nylon ties.

b. Plastic Tape Pipe Markers: Self-adhesive flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings with flow direction arrows and identification of fluid being conveyed.

4. VALVE CHART: Valve chart(s) shall be printed on 8-1/2”x11” white paper with typewritten black text, minimum 12 point character size. Information to be provided shall be, at a minimum, the number, location, size and function of each line valve installed under this Contract. Chart shall be installed in a glazed frame and permanently mounted to wall in mechanical room or other suitable location coordinated with the Owner.

PART 3 - EXECUTION

3.01 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

3.02 GENERAL

A. All markers shall be installed in accordance with manufacturer’s printed instructions, and shall be neat and uniform in appearance. All tags or markers shall be oriented such that they are readily visible from all normal working locations. All equipment above lift-out ceilings or made accessible by access doors shall be labeled in the same manner as that of exposed equipment.

3.03 NAMEPLATES

A. Install plastic nameplates with corrosive resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer. Equipment to be labeled shall include but not be limited to the following items: pumps, exhaust fans, air handling units, fan coil units, VAV boxes, condensing units, chillers, heat exchangers, hot water heaters, boilers, storage tanks, water treatment equipment, air compressors, HVAC control devices and dampers, switches, control panels and other related devices.

3.04 VALVE TAGS

A. Install valve tags on all valves except simple service and drain valves located within 10 feet and sight distance of the device or equipment served. For example, it would not be expected that strainer blow-down values in a machine room would be tagged. Each tag shall be attached to its valve with copper clad annealed iron wire, corrosion resistant chain, or other approved material.

3.05 PIPE MARKERS

A. Exposed piping shall be identified at intervals of 20 feet and at least one time in each room. Provide a pipe marker at each valve. Provide arrow markers at each pipe marker with arrows pointing away from the pipe marker to indicate direction of flow. When flow can be in either or both directions, provide a double ended arrow marker. Provide pipe and arrow marker at every point of pipe entry or exit where line penetrates a wall or service chase. Self-adhesive labels shall be used to identify piping under 6 inches in diameter when insulated and covered. For finished pipe sizes 6 inches and larger, strap type markers with self-locking nylon ties shall be utilized.

3.06 MISCELLANEOUS EQUIPMENT

A. Small items such as inline pumps shall be identified with tags in lieu of nameplates. Submit labeling plan to Engineer for devices and equipment not otherwise specified herein.

END OF SECTION

SECTION 23 05 93
TESTING AND BALANCING AIR AND WATER SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Under this Section, the Contractor shall furnish all labor, materials and equipment for Testing and Balancing Air and Water Systems as shown on the Plans, as specified, and/or directed.

B. Related work specified elsewhere:
   1. Division 1 – General Requirements
   2. Division 23 – Mechanical

1.02 REFERENCE STANDARDS

A. The following is a list of standards that may be referenced in this section:
   1. Associated Air Balance Council (AABC) Publication:
      a. National Standards for Total System Balance (NSFTSB)
   2. National Environmental Balancing Bureau (NEBB) Publication:
      a. Procedural Standards for Testing-Adjusting-Balancing of Environmental Systems
   3. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Publication:
      a. ASHRAE Handbook of Fundamentals
   4. American National Standards Institute (ANSI) Publication:
      a. S1.4 - Specification for Sound Level Meters
      b. S1.11 - Specifications for Octave and Third-
      c. Octave Band Filter Sets

1.03 DEFINITIONS

A. Adjust: To regulate the specified fluid flow rate and air patterns at the terminal equipment, (e.g., reduce fan speed, throttling, etc.)

B. Procedure: Standardize approach and execution of sequence of work operations to yield reproducible results.

C. Report Forms: Test data sheets arranged for collection of test data in logical order to submission and review. This data should also form the permanent record which shall be used as the basis for any future testing, adjusting, and balancing required.

D. Test: To determine quantitative performance of equipment.

1.04 SUBMITTALS

A. An agenda shall be submitted and approved by the Engineer prior to start of testing and balancing work. Include the following:

1. General description of each air and water system with its associated equipment, and operation cycles for heating, intermediate and cooling. Where different cycles are used for day and night, they shall be described independently.
2. A complete listing of all air and water flow and air terminal measurements to be performed.
3. Proposed selection points for sound measurements. List shall include typical spaces and sound sensitive areas including specifically auditoriums and conference rooms.
4. Specific test procedures and parameters for determining specified quantities; e.g., flow drafts, sound levels, etc., from the actual field measurements to establish compliance with Contract requirements.
5. Samples of forms showing applications of procedures and calculations to typical systems.

B. Standards Compliance:
1. Testing Agency
2. Testing Agency Personnel
3. Professional Engineers
4. Instrument Calibration

C. Schedules:
1. Testing Agenda

D. Reports:
1. Preliminary Report
2. Certified Report

1.05 TESTING AND BALANCING AGENCY

A. Air and Water Systems Testing and Balancing: Upon completion of the installation and field testing performance test and adjust the supply, return, make-up, and exhaust air systems, and chilled and heating water systems to provide the air volume and water flow quantities indicated and sound levels required. Accomplish all work in accordance with the agenda and procedures specified and AABC NSFTSB and standards of the National Environmental Balancing Bureau (NEBB). Correct air and water system performance deficiencies disclosed by the test before balancing the systems.

B. Agency Qualifications: The Contractor, as part of this Contract shall obtain the services of a qualified testing organization to perform the testing and balancing work as herein specified. Prior to commencing work under this Section of Specifications, the testing organization shall have been approved by the Engineer. The criteria for determining qualifications shall be membership in the Associated Air Balance Council (AABC), or certification by the National Environmental Balancing Bureau.

C. Owner Selection: If the Contractor fails to submit the name of an acceptable agency, the Engineer may select a firm to accomplish the work, and the selection shall be binding upon the Contractor at no additional cost to the Owner.

1.06 TESTING AGENDA

A. Preliminary Report: Review Plans and Specifications prior to installation of any of the affected system. Submit a written report to the Engineer indicating any deficiencies in the system that would preclude the proper adjusting, balancing, and testing of the systems.

B. Procedure Reporting: Provide specific test procedures for measuring air quantities at terminals. Specify type of instrument to be used, method of instrument application (by sketch), and factors for:
   1. Air terminal configuration
   2. Flow direction (supply or exhaust)
   3. Velocity corrections
   4. Density corrections (unless applicable data are covered elsewhere)

1.07 PROCEDURES AND INSTRUMENTS, GENERAL

A. Requirements: Adjust systems and components thereof that perform as required by Drawings and Specifications.

B. Test Duration: Operating tests of heating and cooling coils, fans and other equipment shall be of not less than four hours duration, after stabilized operating conditions have been established. Capacities shall be based on temperatures and air and water quantities measured during such tests.

C. Instrumentation: Method of application of instrumentation shall be in accordance with the approved agenda. Furnish all personnel, instruments and equipment for tests specified herein.
   1. Accuracy of Instruments: Instruments used for measurements shall be accurate. Provide calibration histories for each instrument for examination. Calibrate each test instrument by an approved laboratory or by the manufacturer. The Engineer has the right to request instrument recalibration, or the use of other instruments and test methodology, where accuracy of readings is questionable.
   2. Application of Instruments: Comply with manufacturer's certified instructions.
   3. Permanently-Installed Instruments: Do not install permanently-installed equipment used for the tests, e.g., gages, thermometers, etc., until just prior to the tests to avoid damage and changes in calibration.
   4. Accuracy of All Thermometers: Plus or minus 1 graduation at the temperatures to be measured. Gradations shall conform with the following schedule:

Medium	Design Temperature Differential (°F)	Maximum Graduation (°F)
Air	10 or less	1/2
Air	over 10	1
Water	10 or less	1/10
Water	10-20	1/2
Water	over 20	1

PART 2 - PRODUCTS

[NOT USED]

PART 3 - EXECUTION

3.01 AIR SYSTEM PROCEDURES

A. Adjustments: Adjust all air handling systems to provide the required design air quantity to, or through, each component. Conduct adjusting and balancing of systems during periods of the year approximating maximum seasonal operation.

B. Equalizers: Adjust equalizing devices to provide uniform velocity across the inlets (duct side for supply of terminals, prior to measuring flow rates).

C. Balance: Use flow adjusting (volume control) devices to balance air quantities only, i.e., proportion flow between various terminals comprising system, and only to the extent that their adjustments do not create objectionable air motion or sound, i.e., in excess of specified limits.
   1. Balancing between runs (submains, branch mains and branches): Use flow regulating devices at, or in, the divided - flow fitting. Minimize restriction imposed by flow regulating devices in or at terminals.
   2. Final Measurements of Air Quantity: Make final measurements of air quantity, after the air terminal has been adjusted to provide the optimum air patterns of diffusion.

D. Fan Adjustment: Total air system quantities, generally, shall be varied by adjustment of fan speeds, or axial-flow fan wheel blade pitch. For systems with direct-connected fans (without adjustable pitch blades), damper restrictions of a system's total flow may be used, only if system pressure is less than 1/2-inch w.g. and sound level criteria is met.

E. Air Measurements and Balancing:
   1. Pitot Tube: Except as specifically indicated herein, make pitot tube traverses of each duct to measure air flow therein. Pitot tubes, associated instruments, traverses, and techniques shall conform with the ASHRAE Handbook Fundamentals.
   2. Pitot Tube Traverse: Except for ducts serving modular office area with movable partitions, which are subject to change, pitot-tube traverse may be omitted if the duct serves only a single room or space and its design volume is less than 200 cfm. In lieu of pitot-tube traverse, determine airflow in the duct by totaling volume of individual terminals served, measured as described herein.
   3. Test Holes: Test holes, specified in Section entitled Ductwork and Accessories, shall be in a straight duct, as far as possible downstream from elbows, bends, take-offs, and other turbulence generating devices, to optimize reliability of flow measurements.
   4. Air Terminal Balancing: Measurement of flow rates by means of velocity meters applied to individual terminals, with or without cones or other adapters, shall be used only for balancing. Measurement of air quantities

at each type of air terminal (inlet and outlet) shall be determined by the method approved for balancing agenda. Conduct laboratory tests to prove accuracy of methodology when so directed by the Engineer. Perform such tests in conformance with ASHRAE Standards.

5. Air Motion and Distribution: As indicated. The Contractor, in addition to air motion measurements, shall make smoke tests wherever requested by the Engineer, to demonstrate the air distribution from air terminals.

3.02 WATER SYSTEM PROCEDURES

A. Adjustment: Adjust heating, cooling, and condensing water systems to provide required quantity to, or through each component.

B. Metering: Measure water quantities and pressures with calibrated meters.

C. Water Measurements and Balancing: Use venturi tubes, orifices, or other metering fittings and pressure gages. Adjust systems to provide the approved pressure drops through the heat transfer equipment (coils (except room units), converters, etc.), prior to the capacity testing. Where flow metering fittings are not installed, determine flow balance by measuring temperature differential across the heat transfer equipment. Perform measurement of temperature differential with the air system, adjusted as described herein, in operation.

D. Automatic Controls: Position automatic control valves for full flow through the heat transfer equipment of the system during tests.

E. Flow: Flow through bypass circuits at three-way valves shall be adjusted to balance that through the supply circuit.

F. Distribution: Adjust distribution by means of balancing devices (cocks, valves and fittings) and automatic flow control valves. Do not use service valves for adjustment. Where automatic flow control valves are utilized in lieu of venturi tubes, record only pressure drop across the valve if said pressure drop is within the pressure drop rating on the valve tag.

3.03 SOUND TEST PROCEDURES

A. General: Tests to demonstrate compliance with sound requirements shall be made at each selection point included in the agenda (Room 205 only).

B. Timing: Take sound level measurements at times when the building is unoccupied, or when activity in surrounding areas and background noise levels in areas tested are at minimum and relatively free from sudden changes in noise levels. Take measurements with all equipment secured, except that being tested. Measure sound levels at any point within a room not less than 6 feet from an air terminal or room unit, and not closer than 3 feet from any floor, wall, or ceiling surface.

C. Meters: Measure sound levels with a sound meter complying with the latest ANSI S1.4. Use the "A" scale to measure overall sound levels. To determine the

specified octave band levels, the above sound levels meter, set on "C" scale, shall be supplemented by an Octave Band Analyzer complying with ANSI S1.11.

D. Equipment Components: Determine "equipment components" of room sound (noise) levels for each (of eight) octave bands as follows:
   1. Measure room sound pressure level "LPb" with equipment to be tested shut off.
   2. Measure room sound pressure level "LPt" with equipment to be tested turned on.
   3. Calculate LPt-LPb; if this value is less than 1, applicable test must be rerun with lower background level (LPb) unless LPt is within sound pressure level specified for equipment.
   4. Determine "C" from table below:

Lpt-LPb (dB)	1	2	3	4-4-1/2	5-5-1/2	6-7-1/2	8-12	Over 12
C	7	4	3	2	1-1/2	1	1/2	O

   5. The "equipment component" of room sound level equals LPt-c.

3.04 REPORTS

A. Submittal: Submit three copies of the reports described herein, covering air and water system performance air motion (fpm), and sound pressure levels, to the Engineer prior to final tests and inspection.

B. Instrument Records: Include types, serial numbers, and dates calibration of all instruments.

C. Reports: Reports shall identify conspicuously items not conforming to contract requirements, or obvious mal-operation and design deficiencies.

D. Certification: The reports shall be certified by an independent Registered Professional Engineer who is versed in the field or air and water balancing and who is not affiliated with any firm involved in the design or construction phases of the project. Certification shall include checking or adherence to agenda, of calculations, of procedures, and evaluation of final summaries.

3.05 AIR SYSTEM DATA

A. The certified report shall include for each air-handling system the data listed below:
   1. Equipment (fan or factory-fabricated station unit):
      a. Installation Data:
         1) Manufacturer and Model
         2) Size
         3) Arrangement, Discharge, and Class
         4) Motor H.P., Voltage, Phase, Cycles, and Full Load Amps
         5) Location and Local Identification Data
      b. Design data: Data listed in schedules on Drawings and Specifications.

c. Fan Recorded (Test) Data:
   1) C.F.M.
   2) Static Pressure
   3) R.P.M.
   4) Motor Operating Amps
   5) Motor Operating B.H.P.

2. Duct Systems:
   a. Duct Air Quantities (Maximum and Minimum) - Main, Submains, Branches, Outdoor (Outside) Air, Total-air, and Exhaust
   b. Individual Air Terminals:
      1) Terminal Identification (Supply or Exhaust Location and Number Designation
      2) Type Size, Manufacturer and Catalog Identification
      3) Design and Recorded Quantities - C.F.M.
      4) Deflector Vane or Diffusion Cone Settings
      5) Applicable Factor for Application, Velocity, Area, etc.
      6) Design and Recorded Velocities - F.P.M. (State "core", "inlet", etc., as applicable)

3.06 WATER SYSTEM DATA

A. Include reports listed below
   1. Pumps:
      a. Installation Data:
         1) Manufacturer and Model
         2) Size
         3) Type Drive
         4) Motor H.P., Voltage, Phase, and Full Load Amps.
      b. Design Data:
         1) G.P.M.
         2) Head
         3) R.P.M.
         4) B.H.P. and Amps
      c. Recorded Data:
         1) Discharge Pressures (Full-Flow and No-Flow)
         2) Suction Pressures (Full-Flow and No-Flow)
         3) Operating Head
         4) Operating G.P.M. (From pump curves if metering is not provided)
         5) No-Load Amps (where possible)
         6) Full-Flow Amps
         7) No-Flow Amps
   2. Steam Heating Equipment:
      a. Installation Data:
         1) Manufacturer, Model and Type
         2) G.P.M.
         3) Inlet (entering) and Outlet (leaving) Temperatures
         4) Water Pressure Drop
      b. Recorded Data:
         1) G.P.M. (if metered)

2) Entering and Leaving Water Temperature - System
3) Water pressure drop
4) Heating (or Cooling) Media Steam Pressure and Temperature and Condensate Temperature, or Entering and Leaving Water Temperature
5) Heating (or Cooling) Media - Flow (G.P.M. or lbs. per hour)

3. Air Heating and Cooling Equipment:
   a. Design Data:
      1) Load in B.t.u.h. or MBH
      2) G.P.M.
      3) Entering and Leaving Water Temperature
      4) Entering and Leaving Air Conditions (D.B. and W.B.)
      5) C.F.M.
      6) Water Pressure Drop
   b. Recorded Data:
      1) Type of Equipment and Identification (location or number designation)
      2) Entering and Leaving Air Conditions (D.B. and W.B.)
      3) Entering and Leaving Water Temperatures
      4) G.P.M. (if metered)
      5) Temperature Rise or Drop
4. Water Chilling Units:
   a. Installation Data:
      1) Manufacturer and Model
      2) Motor H.P., Voltage, Cycles, Phase, and Full Load Amps
      3) Part Load Amperes
      4) G.P.M. - Chiller and Condenser
      5) Water Pressure Drop - Chiller and Condenser
   b. Recorded Data (Chiller and Condenser):
      1) G.P.M.
      2) Water Pressure Drop
      3) Entering and Leaving Water Temperature
      4) Amperes
   c. Recorded Data (Air-Cooled Condensers):
      1) CFM and R.P.M. of fan
      2) Condenser pressure and temperature
      3) Entering and leaving air temperature

3.07 SOUND LEVEL DATA

A. Report: Record data on sound levels taken at each selected location in Room 205 only, as follows:
   1. Source of sound and location.
   2. Diagram or description of relationship of sound source to measuring instrument.
   3. "A" scale readings:
      a. Equipment being tested turned off (ambient)
      b. Equipment being tested turned on (operating conditions)
   4. Reading at each specified octave band frequency:
      a. Equipment being tested turned off (ambient)

b. Equipment being tested turned on (operating condition)

5. "Equipment components" of sound (noise) levels with applicable calculations per "Sound Test Procedure".
6. Graph showing relationship between pressure levels specified and recorded readings.

B. Retest: Subsequent to any correctional construction work, such as acoustic corrections, make measurements to verify that associated air and water quantities, as previously measured, have not been disrupted.

C. Certified Report; Record all sound data, and their locations, after final adjustments or air and water systems involved.

3.08 FIELD TEST

A. General: Make tests to demonstrate that capacities and general performance of air and water systems comply with Contract requirements.
1. Final Inspection; At the time of final inspection, the Contractor shall recheck, in the presence of the Engineer, random selections of data water and air quantities, air motion and sound levels recorded in the Certified Report.
2. Points and areas for recheck: As selected by the Engineer.
3. Measurement and Test Procedures: As approved for work forming basis of Certified Report.
4. Selections for Recheck (Specific Plus Random): In general, selections for recheck will not exceed 25 percent of the total number tabulated in the report, except that special air systems may require a complete recheck for safety reasons.

B. Retests: If random tests elicit a measured flow deviation of ten percent or more from, or a sound level of 2 Db or more greater than that recorded in the Certified Report listings, at ten percent or more of the rechecked selections, the report shall be automatically rejected. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, new Certified Reports submitted, and new inspection tests made.

C. Marking of Settings: Following final acceptance of Certified Reports by the Owner, the settings of all valves, splitters, dampers, and other adjustment devices shall be permanently marked by the Contractor, so that adjustment can be restored if disturbed at any time. Do not mark devices until after final acceptance.

END OF SECTION

SECTION 23 07 00 HVAC INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. Under this Section, the Contractor shall furnish all labor, materials and equipment for HVAC Insulation as shown on the Plans, as specified and/or directed.

B. Related work specified elsewhere:
1. Section 23 05 00 – Mechanical General Requirements
2. Section 23 05 53 – Identification for HVAC Piping and Equipment
3. Section 23 21 13 – Hydronic Piping and Specialties
4. Section 23 23 13 – Refrigerant Piping and Specialties
5. Section 23 31 13 – Ductwork and Ductwork Accessories

1.02 REFERENCE STANDARDS

A. The following is a list of standards that may be referenced in this section:
1. American Society for Testing and Materials (ASTM) Publication:
   a. A167 - Stainless and Heat Resisting Chromium Nickel Steel Plate, Sheet and Strip
   b. C177 - Steady State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus, Test Method
   c. C195 - Mineral Fiber Thermal Insulating Cement
   d. C533 - Calcium Silicate Block and Pipe Thermal Insulation
   e. C534 - Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
   f. C547 - Mineral Fiber Pipe Insulation
   g. C552 - Cellular Glass Thermal Insulation
   h. C553 - Mineral Fiber Blanket and Felt Insulation for Commercial and Industrial Applications
   i. C592 - Mineral Fiber Blanket Insulation and Blanket Type Pipe Insulation (Metal Mesh Covered) (Industrial Type)
   j. C612 - Mineral Fiber Block and Board Thermal Insulation
   k. C795 - Thermal Insulation for Use in Contact with Austenitic Stainless Steel
   l. C916 - Adhesives for Duct Thermal Insulation
   m. C921 - Properties of Jacketing Materials for Thermal Insulation
   n. D227 - Coal Tar Saturated Organic Felt Used in Roofing and Waterproofing
   o. E84 - Surface Burning Characteristics of Building Materials
   p. E96 - Water Vapor Transmission of Materials
2. Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS) Publication:
   a. SP58 - Pipe Hangers and Supports Materials, Design, and Manufacture
   b. SP69 - Pipe Hangers and Supports Selection and Application

3. National Fire Protection Association (NFPA) Publication:
   a. 255 - Surface Burning Characteristics of Building Materials
4. Underwriters Laboratories, Inc. (UL) Publication:
   a. 723 - Tests for Surface Burning Characteristics of Building Materials
5. Uniform Fire Prevention and Building Code of New York State Publication:
   a. 2020 Energy Conservation Construction Code

1.03 SUBMITTALS

A. Manufacturer's Data:
   1. Insulation
   2. Jackets
   3. Casings
   4. Vapor barrier materials
   5. Accessory materials

B. Standards Compliant: Standards compliance labels are required on each container or package:
   1. Insulation
   2. Jackets
   3. Casings
   4. Vapor barrier materials
   5. Accessory materials

1.04 DEFINITIONS

A. Finished Spaces: Spaces used for habitation or occupancy where rough surfaces are plastered, paneled, or otherwise treated to provide a pleasing appearance.

B. Unfinished Spaces: Spaces used for storage or work areas where appearance is not a factor, such as unexcavated spaces and crawl space.

C. Concealed Spaces: Spaces out of sight. For example, above ceilings; below floors; between double walls; furred in areas; pipe and duct shafts; and similar spaces.

D. Exposed: Open to view. For example, pipe running through a room and not covered by other construction.

E. Fugitive Treatments: Treatments subject to deterioration due to aging, moisture, high humidity, oxygen, ozone, and heat. Fugitive materials are entrapped materials that can cause deterioration, such as solvents and water vapor.

F. Outside: Open to view up to 5 feet beyond the exterior side of walls, above the roof, and unexcavated or crawl spaces.

1.05 MANUFACTURER'S STAMP OR LABEL

A. Every package or standard container of insulation, jackets, cements, adhesives, and coatings delivered to the project site for use must have the manufacturer's stamp or label attached giving name of manufacturer, brand, and description of material. Insulation packages and containers shall be asbestos free.

1.06 FLAME SPREAD AND SMOKE DEVELOPED RATINGS

A. In accordance with NFPA 255, ASTM E84 or UL 723, the materials shall have a flame spread rating of not more than 25 and a smoke developed rating of not more than 50.
   1. Materials Tests: Test factory applied materials as assembled. Field applied materials may be tested individually. Use no fugitive or corrosive treatments to impart flame resistance. UL label or satisfactory certified test report from a testing laboratory will be required to indicate that fire hazard ratings for materials proposed for use do not exceed those specified. Flame proofing treatments subject to deterioration due to effects of moisture or high humidity are not acceptable.
   2. Materials Exempt From Fire Resistant Rating: Nylon anchors.
   3. Materials Exempt from Fire Resistant Rating When Installed In Outside Locations, Buried, or Encased In Concrete: PVC casing and glass fiber reinforced plastic casing.

PART 2 - PRODUCTS

2.01 PIPING SYSTEMS INSULATION

A. Piping systems (except buried pipe) requiring insulation, types of insulation required, and insulation thickness shall be as listed in Tables I and II herein. Except for flexible unicellular insulation, insulation thicknesses as specified in Table II shall be one inch greater for insulated piping systems located outside. Unless otherwise specified, insulate all fittings, flanges, and valves, except valve stems, hand wheels, and operators. Use factory premolded, precut, or field fabricated insulation of the same thickness and conductivity as used on adjacent piping. Insulation exterior shall be factory cleanable, grease resistant, non-flaking and non-peeling. Pipe insulation shall conform to the referenced publications in Table I.
   1. Flexible Unicellular Insulation: ASTM C534. The minimum density limit of 4.5 pounds per cubic foot may be waived if all other characteristics of the standard are met.
   2. Piping Insulation Finishes:
      a. All Purpose Jacket: Except calcium silicate and unicellular insulation, provide a factory applied all-purpose jacket with or without integral vapor barrier as required by the service. Provide jackets in exposed locations with a white surface suitable for field painting. Allow a maximum water vapor permeance of 0.05 perm per ASTM E96, a puncture resistance of not less than 50 Beach units, and a minimum tensile strength of 35 pounds force per inch of width.

b. Vapor Barrier Material: Resistant to flame, moisture penetration, and mold growth. Provide vapor barrier material on pipe insulation as required in Table I.

3. Vinyl Lacquer: Two coats of vinyl lacquer finish or equivalent according to the manufacturer's recommendations for unicellular insulation located outside.

2.02 DUCTS (HEATING, VENTILATING AND AIR CONDITIONING SYSTEMS (HVAC)) INSULATION

A. Duct Insulation in Concealed Spaces: Two inch thick mineral fiber flexible resilient blanket insulation with a maximum insulation rating (installed) of R-6, and a maximum conductivity of 0.31 btu in/per hr sq. ft. degree F at 75 degrees F mean temperature as tested in accordance with ASTM C518.

B. Duct Insulation Not in Concealed Spaces: Mineral fiber per ASTM C612, Class 2 (maximum surface temperature 400 degrees F), 3 pcf (pounds per cubic foot) average, 1-1/2 inch thick, inside the building, and a minimum insulation rating (installed) of R-6.

C. Duct Insulation Finishes:

1. All Purpose Jacket: Provide a factory applied all-purpose jacket with or without integral vapor barrier as required by the service. Provide jackets in exposed locations with a white surface suitable for field painting. All purpose jacket shall have a maximum water vapor permeance of 0.05 perm per ASTM E96; a puncture resistance of not less than 50 Beach units; and a tensile strength of not less than 35 pounds force per inch of width.
2. Vapor Barrier Material: Material shall be resistant to flame, moisture penetration, and shall not support mold growth. Provide vapor barrier on all HVAC duct insulation, on except insulation for heating only.

2.03 ADHESIVES, SEALANTS, AND COATING COMPOUNDS

A. Adhesive for Securing Insulation to Metal Surfaces and Vapor Barrier Lap Adhesive (For Use in Building Interior Only): ASTM C916, Type I (an adhesive in which the vehicle is nonflammable in liquid (wet) state and which will pass the edge burning test), or Type II (An adhesive in which the vehicle is nonflammable in the liquid (wet) state and which will not pass the edge burning test).

B. Mineral Fiber Insulation Cement: ASTM C195, thermal conductivity 0.85 maximum at 200 degrees F mean when tested per ASTM C177.

C. Weatherproof Coating: For outside applications use a weatherproof coating recommended by the manufacturer of the insulation and jackets.

2.04 ACCESSORIES

A. Staples: ASTM A167, Type 304 stainless steel outside clinch type.

B. Insulation Bands: 3/4 inch wide; 0.018-inch stainless steel.

C. Anchor Pins: Provide anchor pins and speed washers recommended by the insulation manufacturer.

D. Glass Cloth and Tape: Tape shall be 4 inch wide rolls. Class 3 tape shall be 4.5 ounces per square yard. In lieu of glass cloth and tape, open weave glass membrane may be used.

E. Coal Tar Saturated Organic Felt: ASTM D227, minimum weight of 13 pounds per 100 square feet.

F. Wire: Soft annealed stainless steel, 0.047 inch nominal diameter.

PART 3 - EXECUTION

3.01 PREPARATION

A. Do not insulate materials until all system tests have been completed and surfaces to be insulated have been cleaned of dirt, rust, and scale and dried. Insulate return ducts, outside air intakes and supply ducts to the room outlets, flexible runouts, plenums, casings, mixing boxes, filter boxes, coils, fans, and the portion of air terminals not in the conditioned spaces. Ensure full range of motion of equipment actuators. Modify insulation to avoid obstruction with valve handle, safety relief, etc. Allow adequate space for pipe expansion. Conditioned space shall be defined as an area, room or space normally occupied and being heated or cooled for human habitation by any equipment. Install insulation with jackets drawn tight and cement down on longitudinal and end laps. Do not use scrap pieces where a full length section will fit. Insulation shall be continuous through sleeves, wall and ceiling openings, except at fire dampers in duct systems. Extend all surface finishes to protect all surfaces, ends, and raw edges of insulation. Apply coatings and adhesives at the manufacturer's recommended coverage per gallon. Individually insulate piping and ductwork. Provide a moisture and vapor seal where insulation terminates against metal hangers, anchors and other projections through the insulation on surfaces for which a vapor seal is specified. Keep insulation dry during the application of any finish. Bevel and seal the edges of exposed insulation. Unless otherwise indicated, do not insulate the following:

1. Exposed air conditioning supply and return ducts in air conditioned space that furnish conditioned air 24 hours each day of the cooling season.
2. Exposed heating supply and return ducts in spaces that are heated 24 hours each day of the heating season.
3. Fibrous glass ductwork.
4. Factory preinsulated flexible ductwork.
5. Factory insulated ductwork, plenums, casings, mixing boxes, filter boxes.
6. Vibration isolating connections.
7. Adjacent insulation.
8. ASME stamps.
9. Fan name plates.
10. Access plates in fan housings.

3.02 PIPING INSULATION

A. Pipe Insulation (Except Unicellular Insulation): Installation of HVAC insulation including materials and workmanship shall be in accordance with the New York State Energy Conservation Construction Code, except as modified herein. Place sections of insulation around the pipe and joints tightly butted into place. The jacket laps shall be drawn tight and smooth. Secure jacket with fire resistant adhesive, factory applied self-sealing lap, or stainless steel outward clinching staples spaced not over 4 inches on centers and l/2 inch minimum from edge of lap. Cover circumferential joints with butt strips, not less than 3 inches wide, of material identical to the jacket material. Overlap longitudinal laps of jacket material not less than 1-1/2 inches. Adhesive used to secure the butt strip shall be the same as used to secure the jacket laps. Apply staples to both edges of the butt strips. When a vapor barrier jacket is required, as indicated in TABLE I, or on the ends of sections of insulation that butt against flanges, unions, valves, and fittings, and joints, use a vapor barrier coating or manufacturer's weatherproof coating for outside service. Apply this vapor barrier coating at all longitudinal and circumferential laps. Patch damaged jacket material by wrapping a strip of jacket material around the pipe and cementing, stapling, and coating as specified for butt strips. Extend the patch not less than l-l/2 inches past the break in both directions. At penetrations by pressure gauges and thermometers, fill the voids with the vapor barrier coating for outside service. Seal with a brush coat of the same coating. Do not use staples to secure jacket laps on pipes carrying fluid medium at temperatures below 35 degrees F. Where penetrating roofs, insulate piping to a point flush with the top of the flashing and seal with the vapor barrier coating. Butt tightly the exterior insulation to the top of the flashing and interior insulation. Extend the exterior metal jacket 2 inches down beyond the end of the insulation. Seal the flashing and counterflashing underneath with the vapor barrier coating. In cold water piping in high humidity areas, use cellular glass, or flexible unicellular insulation.

B. Flexible Unicellular Insulation: Bond cuts, butt joints, ends, and longitudinal joints with adhesive. Miter 90 degree turns and elbows, tees, and valve insulation. Where pipes penetrate fire walls, provide mineral fiber insulation inserts and sheet metal sleeves. Insulate flanges, unions, valves, and fittings in accordance with manufacturer's published instructions. Apply two coats of vinyl lacquer finish to flexible unicellular insulation in outside locations.

C. Hangers and Anchors: Pipe insulation shall be continuous through pipe hangers. Where pipe is supported by the insulation, provide MSS SP 58, Type 40 galvanized steel shields or MSS SP 58, Type 39 protection saddles conforming to MSS SP 69. Where shields are used on pipes 2 inches and larger, provide insulation inserts at points of hangers and supports. Insulation inserts shall be of cellular glass (minimum 8 pcf), molded glass fiber (minimum 8 pcf), or other approved material of the same thickness as adjacent insulation. Inserts shall have sufficient compressive strength to adequately support the pipe without compressing the inserts to a thickness less than the adjacent insulation. Insulation inserts shall cover the bottom half of the pipe circumference 180 degrees and be not less in length than the protection shield. Vapor barrier facing of the insert shall be of the same material as the facing on the adjacent

insulation. Seal inserts into the insulation with vapor barrier coating, or for exterior work, manufacturers recommended weatherproof coating, as applicable. Where protection saddles are used, fill all voids with the same insulation material as used on the adjacent pipe.

D. Sleeves and Wall Chases: Where penetrating interior walls, extend a metal jacket 2 inches out on either side of the wall and secure on each end with a band. Where penetrating floors, extend a metal jacket from a point below the back-up material to a point 10 inches above the floor with one band at the floor and one not more than one inch from end of metal jacket. Where penetrating exterior walls, extend the metal jackets through the sleeve to a point 2 inches beyond the interior surface of the wall.

E. Flanges, Unions, Valves and Fittings Insulation (Except Flexible Unicellular) for Hot Piping: Factory fabricated removable and reusable insulation covers may be used. For inside heating hot water systems, place factory premolded, precut or field fabricated segmented insulation of the same thickness and conductivity as the adjoining pipe insulation around the flange, union, valve, and fitting abutting the adjoining pipe insulation. If nesting size insulation is used, overlap 2 inches or one pipe diameter whichever is larger. Use insulating cement to fill voids. Elbows insulated using segments shall have not less than three segments per elbow. Place and joint the segments with manufacturer's recommended water vapor resistant, fire retardant, and adhesive appropriate for the temperature limit of the service. Upon completion of installation of insulation, apply two coats of lagging adhesive with glass tape embedded between coats. Overlap tape seams one inch. Extend adhesive onto adjoining insulation not less than two inches. The total dry film thickness shall be not less than 1/16 inch. Where unions are indicated not to be insulated, taper the insulation to the union at a 45 degree angle. Coat the insulation and all-purpose jacket with two coats of lagging adhesive and with glass tape embedded between coats. The total dry film thickness shall be not less than 1/16 inch. At the option of the Contractor, factory premolded one piece PVC fitting covers may be used in lieu of two coats of adhesive with tape embedded between coats. Factory premolded field fabricated segment or blanket insert insulation shall be used under the fitting covers. Install factory premolded one piece PVC fitting covers over the insulation and secure by stapling, taping with PVC vapor barrier tape, or with metal or plastic tacks made for securing PVC fitting covers. Do not use PVC fitting covers where exposed to the weather. Limit the use of PVC fitting covers to ambient temperatures below 150 degrees F.

F. Flanges, Unions, Valves, Anchors, Fittings for Cold Piping: Factory fabricated removable and reusable insulation covers may be used. For piping insulation inside the building that service chilled water supply and return, refrigerant suction, and A/C condensate drains, coat pipe insulation ends with vapor barrier coating not more than six inches from each flange, union, valve, anchor or fitting. Place insulation of the same thickness and conductivity as the adjoining pipe insulation (either premolded or segmented) around the item, butting the adjoining pipe insulation. If nesting size insulation is used, overlap the insulation 2 inches or one pipe diameter. Use loose fill mineral wool or insulating cement to fill the voids. Elbows insulated using segments shall not have less than 3 segments per

elbow. Insulation may be secured by wire or tape until finish coating is applied. Apply two coats of vapor barrier coating with glass tape embedded between coats. Overlap tape seams one inch. Extend the coating out onto the adjoining pipe insulation 2 inches. Where unions are shown not to be insulated, the insulation shall be tapered to the union at a 45 degree angle. Seal the insulation and jacket with two coats of vapor barrier coating with glass tape embedded between coats. Insulate anchors attached directly to the pipe for a sufficient distance to prevent condensation but not less than 6 inches from the insulation surface. Insulate flexible connections at pumps and other equipment with unicellular plastic insulation, unless otherwise indicated. At the option of the Contractor, premolded, one piece polyvinyl chloride (PVC) fitting covers may be used in lieu of the embedded glass tape. Factory premolded insulation or field fabricated insulation segments shall be used under the fitting covers. Blanket inserts may be used. Secure the covers with adhesive and vapor barrier tape with a vapor resistance of maximum 0.05 perm per ASTM E96, or with tacks made for securing PVC covers. Then coat all tape seams and tacks with Type II vapor barrier coating. Do not use premolded PVC fitting covers where exposed to weather. Limit the use of PVC covers to not less than 35 degrees F medium temperatures and below 150 degrees F ambient temperatures.

3.03 DUCTS (HVAC) INSULATION

A. Rigid Insulation: Secure rigid insulation by impaling over pins or anchors located not more than 3 inches from joint edges of boards, spaced not more than 12 inches on centers and secure with washers and clips. Spot weld anchor pins or attach with a waterproof adhesive especially designed for use on metal surfaces. Apply insulation with joints tightly butted. Neatly bevel insulation around name plates and access plates and doors. Each pin or anchor shall be capable of supporting a 20 pound load. Cut off protruding ends of pins, after clips are sealed with coating compound for inside work or manufacturer's recommended weatherproof coating for outside work, and reinforced with open weave glass membrane.

B. Flexible Blanket Insulation: Apply insulation with all joints tightly butted. Secure insulation to ductwork with adhesive in 6 inch wide strips on 12 inch centers. Staple laps of jacket with outward clinching staples and seal with foil scrim kraft (FSK) tape. For ductwork over 24 inches on horizontal duct runs, provide pins, washers and clips. Use pins on sides of vertical ductwork being insulated. Space pins and clips on 18 inch centers and not more than 18 inches from duct corners. Carry insulation over standing seams and trapeze type hangers. Install speed washers with pins and pin trimmed to washer. Sagging of flexible duct insulation will not be permitted. Cut off protruding ends of pins after clips are secured and sealed with coating compound for inside work. For warm air ducts, overlap insulation not less than 2 inches at joints and secure the laps with outward clinch staples on 4 inch centers. In cold air ducts, vapor seal all joints and staple as specified.

C. Insulation Finishes and Joint Sealing: Fill all breaks, punctures, and voids with vapor barrier coating compound for inside work or manufacturers recommended weatherproof coating for outside service. Vapor seal all joints by embedding a single layer of 3 inch wide open weave glass membrane, 20 by 20 mesh

maximum size between two 1/16 inch wet film thickness coats of vapor barrier coating compound. Draw glass fabric smooth and tight with a 1-1/2 inch overlap. At jacket penetrations such as hangers, thermometers, and damper operating rods, fill voids in the insulation with vapor barrier coating. Brush a coat of vapor barrier coating where required on HVAC ducts. Provide vapor barrier jacket continuous across seams, reinforcing, and projections. Where height of projections is greater than insulation thickness, carry insulation and jacket over the projection. For joints for heating only systems, provide insulation with two coats of fire resistant adhesive with glass fabric 20 by 20 maximum size mesh embedded between coats.

D. Access Plates and Doors: On acoustically lined ducts, plenums, and casings, provide insulation on access plates and doors. On externally insulated ducts, plenums, and casings, provide insulation filled hollow steel panels and doors for access openings. Bevel insulation around access plates and doors.

3.04 PAINTING AND IDENTIFICATION

A. Paint in accordance with Section 09 91 23, "Interior Painting". Piping identification shall be as specified in Section 23 05 53, “Identification of HVAC Piping and Equipment”.

3.05 REPLACEMENT OF EXISTING ASBESTOS INSULATION

A. Section 02 82 00, "Removal and Disposal of Asbestos". When existing asbestos insulation is to be replaced, provide new asbestos free insulation. Label or stencil new insulation "Asbestos Free" after final finishing and painting.

3.06 FIELD INSPECTION

A. Visually inspect to ensure that materials used conform to specifications. Inspect installations progressively for compliance with requirements.

TABLE I
INSULATION MATERIAL FOR PIPING

SERVICE	MATERIAL	SPEC.	TYPE	CLASS	VAPOR BARRIER REQUIRED
Chilled Water (Supply & Return) Piping	Cellular Glass	ASTM C552	II	2	No
	Flexible Unicellular	ASTM C534	I or II		No
	Mineral Fiber	ASTM C547		1	Yes
Refrigerant Suction Piping	Flexible Unicellular	ASTM C534	I or II		No
Heating Hot Water (Supply & Return)	Cellular Glass	ASTM C552	II		No
	Mineral Fiber	ASTM C547		1	No
*A/C Condensate	Mineral Fiber	ASTM C547		1	Yes

TABLE I
INSULATION MATERIAL FOR PIPING

SERVICE	MATERIAL	SPEC.	TYPE	CLASS	VAPOR BARRIER REQUIRED
Drain Located Inside Bldg.	Cellular Glass	ASTM C552	II	2	No
	Flexible Unicellular	ASTM C534	I or II		No
	Calcium Silicate	ASTM C533	I		

*NOTE: If there is no condensation condition existing, insulation is not required for CPVC or PVC piping.

TABLE II
PIPING INSULATION WALL THICKNESS

SERVICE	MATERIAL	TUBE AND PIPE SIZE (INCHES)				
		1/4 - 3/4	1 – 1-1/4	1-1/2 - 3	4 - 6	8+
Chilled Water (Supply & Return) Piping	Mineral Fiber	1/2	1/2	1	1	1
	Cellular Glass	1/2	1/2	1	1	1
	Flexible Unicellular	1/2	1/2	1	1	1
A/C Condensate Drain Located Inside Bldg.	Mineral Fiber	1	1	1-1/2	1-1/2	1-1/2
	Cellular Glass	1	1	1-1/2	1-1/2	1-1/2
	Flexible Unicellular	1	1	1-1/2	1-1/2	1-1/2
Refrigerant Suction Piping	Flexible Unicellular	1-1/2	1-1/2	2	2	2
Heating Hot Water (Supply & Return)	Cellular Glass	1-1/2	1-1/2	2	2	2
	Mineral Fiber	1-1/2	1-1/2	2	2	2

*NOTE: Insulation located outside shall be one inch thicker than that shown in table above.

END OF SECTION

SECTION 23 09 23
DIRECT DIGITAL CONTROL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Under this Section, the Contractor shall furnish all labor, materials and equipment for Direct Digital Control Systems as shown on the Plans, as specified and/or directed.

B. Related Work specified elsewhere:
1. Division 1 – General Requirements
2. Section 23 05 00 – Mechanical General Requirements
3. Section 23 05 93 – Testing and Balancing Air and Water Systems
4. Section 23 31 13 – Ductwork and Ductwork Accessories
5. Section 23 34 01 – HVAC Fans
6. Section 23 81 26 – Unitary Air Conditioning Systems
7. Division 26 – Electrical

1.02 REFERENCE STANDARDS

A. The following is a list of standards that may be referenced in this section:
1. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE) Publication:
   a. 135 – BACnet Standard
2. American National Standards Institute, Inc. (ANSI) Publication:
   a. B31.1 – Power Piping
   b. B40.1 – Gauges Pressure, Indicating Dial Type Elastic Element
   c. C12.10 – Watt hour Meters
   d. C57.13 – Requirements for Instrument Transformers
   e. MC85.1 – Terminology for Automatic Control
   f. X3.4 – Information Systems - Coded Character Sets – 7-Bit American National Standard Code for Information Interchange (7 Bit ASCII)
3. Electronic Industries Association (EIA) Publication:
   a. RS-232-D – Interface Between Data Terminal Equipment and Data Circuit Terminating Equipment Employing Serial Binary Data Interchange
4. Institute of Electrical and Electronics Engineers, Inc. (IEEE) Publication:
   a. 472 – Guide for Surge Withstand Capability (SWC) Tests
5. National Electrical Manufacturers Association (NEMA) Publication:
   a. 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
   b. DC-3 – Wall-Mounted Room Thermostats
6. National Fire Protection Association (NFPA) Publication:
   a. 70 – National Electrical Code
   b. 90A – Installation of Air Conditioning and Ventilating Systems
7. Underwriters Laboratories Inc. (UL) Publication:
   a. Fire Protection Equipment Directory

b. 486A – Wire Connectors and Soldering Lugs for Use with Copper Conductors
c. 506 – Specialty Transformers
d. 916 – Energy Management Equipment

8. Uniform Fire Prevention and Building Code of New York State Publication:
   a. 2020 – Mechanical Code of New York State
   b. 2020 – Energy Conservation Construction Code of New York State

1.03 SYSTEM DESCRIPTION

A. Provide new complete DDC Native BACNet-based system, including associated equipment, programming, software, hardware and appurtenances. Provide each system complete and ready for operation. The new system shall incorporate, completely integrate and upgrade the existing HVAC equipment controllers and end user access devices in the facility, including three (3) air handling units, six (6) fan coil units, chiller and pump system, boiler and pump system, exhaust fans, louvers, seven (7) room temperature sensors, two (2) display controllers, and damper and valve operators. The new system shall incorporate the new HVAC equipment being provided, including one fan coil unit with hot water and chilled water valves, valve operators and controls, exhaust fan, and gravity ventilator. Existing control and network wiring, and IP network connection shall be tested and reused. Manufacturer's products, including design, materials, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with ANSI B31.1 and NFPA 70, except as modified herein or indicated otherwise. In ANSI B31.1 and NFPA 70, consider the advisory provisions mandatory. Substitute the word "shall" for "should" wherever it appears; interpret reference to the "Authority having jurisdiction" and "Owner" to mean the Engineer. Provide DDC systems to maintain the conditions indicated, to perform the functions indicated, and to operate in the sequence specified or indicated. Provide DDC systems with electric operators. Electric or electronic controllers may be used only for terminal unit controls. Control equipment, valves, panels, and dampers shall bear the manufacturer's nameplate and be BTL (BACnet Testing Laboratory) tested and listed. The DDC system shall be Reliable Controls Inc., or approved equal. Section 23 05 00, “Mechanical General Requirements" applies to this section, with the additions and modifications specified herein.

1. Provide wiring and conduit required to connect control devices furnished as a part of the system. Control wiring is defined as wiring up to and including 120 volts. Install wiring in accordance with requirements of Division 26 and the National Electrical Code. Provide and install all required devices for proper system operation, including special electrical switches, transformers, relays, pushbutton stations, etc.

1.04 SUBMITTALS

A. Shop Drawings:

1. Temperature control system schematic, including required variables, flow diagrams, ladder diagrams, (I/O) list, and point to point wiring diagrams, indicating set points, reset ranges, throttling ranges, controller gains,

differentials, operating ranges, normal positions, controller action, dial ranges, voltages, currents, mounting locations, indicators, and terminal strip points
2. Sequence of operation for each system and function
3. Generic, functional description of each control component indicated
4. Equipment interlocks required by sequence of operation
5. Automatic valve schedule showing flow, C v, and pressure drop

B. Manufacturer's Data:
1. Fan coil unit (FCU), valves and operators
2. Input/output (I/O) modules, interface terminal, and controllers, including complete wiring and connection diagrams
3. Temperature sensors, including complete wiring and connection diagrams
4. Temperature and pressure indicators, including complete wiring and connection diagrams
5. Pressure sensors, including complete wiring and connection diagrams;
6. Air flow monitoring stations
7. Switches, relays, transmitters, transformers, including complete wiring and connection diagrams

C. Certified Test Reports:
1. Valve flow characteristics
2. Damper leakage rates
3. Inherent flow characteristics of each damper
4. Valve and damper operator power characteristics
5. Field acceptance report

D. Certificates of Compliance:
1. Valves

E. Field Acceptance Inspections and Tests: Includes check-out and certification forms for all devices and systems.

1.05 CONTRACTOR EXPERIENCE AND QUALIFICATIONS:

A. The Contractor or subcontractor that will perform the work, with whom the Contractor has a firm contractual agreement, shall have completed at least three DDC systems installations of the same type and design specified, that have successfully operated for at least two years.

1.06 OPERATIONS AND MAINTENANCE MANUALS

A. Manuals shall include approved items of equipment and drawings provided under paragraphs titled "Shop Drawings" and "Manufacturer's Data" of this section combined to provide a consolidated operation and maintenance manual. Manual shall contain full hardware support documentation, which shall include but not be limited to the following:
1. General description and specifications
2. Installation and initial checkout procedures
3. Detailed electrical and logical description
4. Complete troubleshooting procedures, diagrams, and guidelines

5. Complete alignment and calibration procedures for components
6. Preventive maintenance requirements
7. Detailed system schematics, system field assembly drawings, and system component specifications and dimensions
8. Complete spare parts lists
9. Interface requirements and capabilities
10. Signal identification and timing diagrams
11. Complete as built control drawings, schedules, and sequence of operation

PART 2 - PRODUCTS

2.01 MATERIALS

A. General: Except as otherwise noted, the control system shall consist of all Ethernet Network Controllers, Standalone Digital Control Units, input/output modules, file servers, software, sensors, transducers, relays, valves, damper operators and other accessory equipment, along with a complete system of electrical interlocking wiring as required to fill the intent of the specification and provide for a complete and operable system. All interlocking, wiring and installation of control devices associated with the equipment shall be provided. Control panels shall be fully enclosed cabinet, baked enamel, steel, aluminum or composite material construction and shall meet the requirements of NEMA 1 enclosures. Panels shall have hinged door with a locking latch. Each component on front panel and inside the panel shall have an appropriate engraved label describing its function.

1. The DDC system shall provide equipment control, alarm detection, scheduling, reporting and information management for the entire facility. The system shall be scalable and expandable at all levels of the system using the same software interface and controllers. The system design shall include solutions for the integration of the following “open systems” protocols: BACnet, LonTalk and digital data communication to third party microprocessors.

2.02 SYSTEM COMPONENTS

A. Provide sensors compatible with the DDC equipment provided and with accuracies as stated herein. Coordinate instrument characteristics such as hysteresis, relaxation time, span, including maximum and minimum limits, for each application of the sensors and controls, so the control system operates smoothly and accurately throughout the design range.

1. Valves: Two position valves shall be line size or sized using a pressure differential of 1 psi. Two-way modulating valves shall be sized using a pressure differential of 5 psig or twice the load pressure drop, whichever is more. Three-way modulating valves shall be sized using twice the load pressure drop, but not more than 5 psig. Close-off pressure rating shall be 100 PSI, except ¾” and smaller terminal units which shall be 200 PSI.
   a. NPS 2 or smaller: Nickel-plated forged brass body rated at no less than 400 psi, stainless steel ball and blowoff proof stem, female NPT end fittings, with dual EPDM O-ring packing design,

fiberglass reinforced Teflon seats, and a TEFZEL flow characterizing disc.

b. NPS ¾ and smaller for terminal units: Nickel-plated forged brass body rated at no less than 600 psi, stainless steel ball and blowoff proof stem, female NPT end fittings, with dual EPDM O-ring packing design, fiberglass reinforced Teflon seats, and a TEFZEL flow characterizing disc.

B. Operators: Provide 24V electric motor type, 0-10 VDC input proportional, or two position with spring return so that, in the event of power failure, operators shall FAIL SAFE in either the normally open or normally closed position as indicated or specified. Operator shall be synchronous motor driven with up to 150 in. lb. force sensor safety stop and return as required. Operators shall be quiet operating and function properly within range of 85 to 110 percent of the motive power of the system.

C. Current Measurement Devices: Measurement of three-phase power shall be accomplished with a kW/kWh transducer. The instrument shall utilize direct current transformer inputs to calculate the instantaneous value (kW) and a pulsed output proportional to the energy usage (kWh).

D. Network Controllers: Provide microprocessor based direct digital control of modular design located where indicated with integral power supply connected to the building 120 V AC power circuit which shall function as a standalone system and which shall include all required resident software programs to provide the specified sequence of operation. System shall have a programmable DC power backup system rated for a minimum of 72 hours of battery backup to maintain all volatile memory. This power backup system shall be configurable such that at the end of a settable timeframe of running on full UPS, the unit shall shut off full UPS and switch to memory retention-only mode for the remainder of the battery power. The system shall allow the simple addition of more batteries to extend the above minimum battery backup times. Upon restoration of power after an outage, the Network Controller shall automatically and without human intervention update all monitored functions; resume operation based on current, synchronized time and status; and implement special start-up strategies as required. The network controller shall have the ability to store HTML code and “serve” pages to a web browser, such that any computing device utilizing TCP/IP Ethernet connection and capable of running a standard Internet browser (Chrome, Edge, Firefox, IE 8 or greater, Safari) to access real-time data from the entire Temperature Control System via any Network Controllers. The system shall also include the following:

1. Graphics and text-based web pages shall be constructed using standard HTML code. The interface shall allow the user to choose any of the standard text or graphics-based HTML editors for page creation. It shall also allow the operator to generate custom graphical pages and forms.
2. The WEB server interface shall be capable of password security, including validation of the requesting PC's IP address. The WEB server interface shall allow the sharing of data or information between any controller or process or network interface (BACnet, LonTalk and TCP/IP) that the Temperature Control System has knowledge of, regardless of

where the point is connected on the Temperature Control System network or where it is acquired from.

3. The network controller shall act directly as the WEB server. It shall directly generate HTML code to the requesting user (i.e. WEB browser), eliminating the need for and reliance on any PC-based WEB server hardware or software. To simplify graphic image space allocation, HTML graphic images shall be stored in any shared network device. The Web server shall have the ability to acquire any necessary graphics using standard pathing syntax within the HTML code mounted within the Temperature Control System WEB server.
4. The system shall incorporate a dedicated cellular modem for remote web-based access. The mobile access to provide critical status, setpoints and alerts. The system shall also provide email alerts via dedicated mail server.
5. Hardware: A minimum of 8MB of RAM shall be provided for Network Controllers. Each Network Controller shall provide communication to both the Workstation(s) and the field buses. In addition, each Network Controller shall have at least three other communications ports that support a portable service tool, serial printer and connection to third party controllers such as a boiler control panel.
    a. Input/Output (I/O) Functions: Modular I/O design shall allow for easy expansion, with the capacity provided through plug-in modules of various types or DIN-mountable IOU modules. It shall be possible to combine I/O modules as desired to meet the I/O requirements for individual control applications. Each Network Controller shall support the addition of the following types of inputs and outputs:
        1) Digital Inputs for status/alarm contacts.
        2) Counter Inputs for summing pulses from meters.
        3) Thermistor inputs for measuring temperatures in space, ducts and thermowells.
        4) Analog inputs for pressure, humidity, flow and position measurements.
        5) Digital Outputs for on/off equipment control.
        6) Analog Outputs for valve and damper position control, and capacity control of primary equipment.
    b. Time Clock: Each Network Controller shall include a battery-backed, real time clock, accurate to ±1 second per day. The Real Time Clock shall provide the following: time of day, day, month, year, and day of week. In normal operation, the system clock shall be based on the frequency of the AC power. The system shall automatically correct for daylight savings time and leap years.
6. Software Resident in the Microprocessor: Provide the following routines as a minimum:
    a. Proportional, integral plus derivative control (PID) and on off two-position control outputs;
    b. Required controller action;
    c. Sequencing of control action in any order;
    d. Digital filter;
    e. Ratio calculator;
    f. Remote reset of control functions;

g. Equipment Cycling Protection; and
h. Mathematical Functions: Each controller shall be capable of performing basic mathematical functions (+, *, /), squares, square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc. These shall be able to be used in the same equations with the mathematical operators and nested up to five parentheses deep.
i. Energy Management Applications: Network Controllers shall have the ability to perform all of the following energy management routines:
   1) Time of Day Scheduling
   2) Calendar Based Scheduling
   3) Holiday Scheduling
   4) Temporary Schedule Overrides
   5) Optimal Start
   6) Optimal Stop
   7) Night Setback Control
   8) Enthalpy Switchover (Economizer)
   9) Peak Demand Limiting Temperature
   10) Compensated Duty Cycling
   11) CFM Tracking
   12) Heating/Cooling Interlock
   13) Free Cooling
   14) Hot Water Reset
   15) Static Pressure Reset/Optimizing
   16) Demand Controlled Ventilation
   17) Supply Air Temperature Reset

   Any system variables (inputs, outputs, math calculations, flags, etc.) can be logged in history. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logs can be automatic or manual. Logged data shall be downloadable to the Operator Workstation for long tern archiving based upon user-defined time intervals, or manual command.

7. Alarm Management: For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms shall be tested each scan of the Network Controller and can result in the display of one or more alarm messages or reports.
   a. Up to eight (8) alarms can be configured for each point in the controller.
   b. Messages and reports can be sent to a local terminal, to the front-end workstation(s), or via modem to a remote-computing or cellular device.
   c. Alarms shall be generated based on their priority. A minimum of 255 priority levels shall be provided.
   d. If communication with the Operator Workstation is temporarily interrupted, the alarm shall be buffered in the Network Controller. When communications return, the alarm shall be transmitted to the Operator Workstation if the point is still in the alarm condition.

The Network Controller shall be able to generate user-definable reports to a locally connected printer or terminal. The reports shall contain any combination of text and system variables. Report templates shall be able to be created by users in a word processing environment. Reports can be displayed based on any logical condition or through a user command.

E. Standalone Controllers: Standalone controllers shall provide control of HVAC. Each controller shall have its own control programs and shall continue to operate in the event of a failure or communication loss to its associated Network Controller. Standalone controller programs shall be stored in battery back-up RAM and EPROM, and provide a communication port to the field bus. In addition, a port shall be provided for connection of a portable service tool to support local commissioning and parameter changes with or without the Network Controllers online. It shall be possible from a service port on any Standalone Controller to view, enable/disable, and modify values of any point or program on any controller on the local field bus, any Network Controller or any Standalone Controller on a different field bus.

1. Input and Output (I/O): Each standalone controller shall support the addition of the following types of inputs and outputs:
   a. Digital Inputs for status/alarm contacts.
   b. Counter Inputs for summing pulses from meters.
   c. Thermistor Inputs for measuring temperatures in space, ducts and thermowells.
   d. Analog inputs for pressure, humidity, flow and position measurements.
   e. Digital Outputs for on/off equipment control.
   f. Analog Outputs for valve and damper position control, and capacity control of primary equipment.

   Input and output capacity shall be expandable through the use of plug-in modules. A minimum of two (2) modules shall be added to the base Standalone Controller before additional power is required.
2. Each Standalone Controller shall be able to exchange information on a peer to peer basis with other Standalone Controllers during each field bus scan. Each Standalone Controller shall be capable of storing and referencing global variables (on the LAN) with or without any workstations online. Each Standalone Controller shall be able to have its program viewed and/or enabled/disabled either locally through a portable service tool or through a workstation connected to a Network Controller. Standalone Controllers shall have as a minimum, LED indication of CPU status, and field bus status. Upon restoration of power, the Standalone Controller shall automatically and without human intervention, update all monitored functions, resume operation based on current, synchronized time and status, and implement special start-up strategies as required. Each Standalone Controller shall have at least ten (10) years of back up to maintain all volatile memory.
3. For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms shall be tested each scan of the Standalone Controllers and can result in the display of one or more alarm messages or reports.

a. Up to eight (8) alarms can be configured for each point in the controller enabling the escalation of the alarm priority (urgency) based upon which alarm(s) is/are triggered.
b. Alarm messages can be sent to a local terminal or modem connected to a Network Controller or to the Operator's Workstation(s).
c. Alarms shall be generated based on their priority. A minimum of 255 priority levels shall be provided.
d. If communication with the Network Controller is temporarily interrupted, the alarm shall be saved in the Standalone Controller. When communications return, the alarm shall be transmitted to the Network Controller if the point is still in the alarm condition.

4. Air Handler Controllers shall be capable of meeting the requirements of the sequence of operation intended for each system and allow for future expansion.
   a. Air Handling Unit Controllers shall support all the necessary point inputs and outputs as required by the sequence and operate in a standalone fashion.
   b. Air Handling Unit Controllers shall be fully user programmable to allow for modification of the application software.
   c. An LCD display shall be optionally available for readout of point values and to allow operators to change setpoints and system parameters.

F. Temperature Sensors: All temperature devices shall use precision thermistors accurate to + 0.18°F over a range of -40 to 250°F. Duct temperature sensors shall incorporate a thermistor bead embedded at the tip of a stainless steel tube. Probe style duct sensors shall be used in air handling applications where the air stream temperature is consistent and is not stratified.

G. Pressure Sensors: Sensor integrity and accuracy shall not be affected by shock, vibration, and pressure surges of 150 percent of working pressure range or 25 psig above or below scale. Provide sensors with external adjustable span and adjustable zero elevation and suppression. Provide combined linearity/hysteresis and span shift accuracy plus or minus 0.25 percent of full scale. Provide stainless steel type pressure sensors with the following characteristics:
   1. Ambient Temperature: 40 to 140 degrees F temperature compensated range.
   2. Isolation Valves: Provide a three valve manifold for sensors installed on liquid piping for isolation and nulling.
   3. Static Pressure Analog: Provide circuits and A/D convertors for required full scale range. Sensors shall have a sensor span of: 0 to 5 inches W.G.
   4. Differential Pressure Analog: Provide bellows or filled diaphragm sensor with solid state preamplifier. Sensors shall include the following:
      a. Sensor Span: 0 to 25 psi as indicated.
      b. Pressure: Sensor shall withstand minimum overpressure of 200 percent of working pressure and full vacuum under pressure without damaging sensor or affecting sensor accuracy.

H. Flow Sensors: Provide as indicated. Provide combined linearity/hysteresis and span shift accuracy plus or minus 0.25 percent of full scale. Mount sensors in nonpublic spaces.
   1. Liquid Sensors: Orifice, nozzle, venturi or turbine type.
   2. Air Sensors: Averaging pitot tube or averaging mass flow type.

I. Thermostats: Standard space sensors shall be provided in an enclosure for mounting on a standard electrical box. Provide different types of zone sensors as indicated on drawings. Sensor types shall include zone temperature monitoring only with no local temperature control, limited occupant temperature control and timed occupancy overrides, and universal digital display of the zone temperature including occupant temperature control and timed occupancy overrides.

J. Insertion Freeze Protection Thermostatic Switch: Electric switch shall be bulb and capillary type. Provide special purpose insertion thermostats with flexible elements a minimum of 20 feet in length for coil face areas up to 80 square feet. Provide additional elements or longer elements for larger coils at the rate of one foot length of element per 4 square feet of coil. Serpentine capillary in a plane perpendicular to the airflow to uniformly sense the entire airflow. A freezing condition at any one foot increment anywhere along the sensing element shall activate the thermostatic switch. Switch shall require manual reset after activation.

K. Immersion Limit Thermostatic Switch: Provide immersion or remote switch with liquid filled sensing elements for electric types for immersion into fluids in tanks or pipes and equipped with separable wells. Rate wells for minimum of ANSI Class 125 working pressures. Provide heat sensitive transfer agent between exterior surface of sensing element and interior surface of separable well.

2.03 ELECTRICAL AND ELECTRONIC POWER SUPPLY AND WIRING

A. Provide a source 120 volts or less, 60 Hz, two pole, three wire with ground. Power for electric motors 0.5 hp and larger shall be three phase, 208 volt or more, 60 Hz. Devices shall be UL listed or FM approved.

B. Transformers: Provide step down transformers where control equipment operates at lower than line circuit voltage. Transformers serving individual heating, ventilating, and air conditioning units shall be fed from the fan motor leads, or fed from the nearest distribution panelboard or motor control center, using circuits provided for the purpose. Transformers, other than transformers in bridge circuits, shall have primaries wound for the voltage available and secondaries wound for the correct control circuit voltage. Size transformers so that 80 percent of the rated capacity equals the connected load. Provide a disconnect switch on the primary side and a fuse cutout on the secondary side. Transformers shall conform to UL 506.

C. Relays: Provide open contact, mercury tube, or electronic type with dustproof enclosures.

D. Manual Transfer Switches: Provide with operating levers and index plates showing switch positions and names of apparatus controlled or other appropriate designations.

E. Wiring: Provide copper wiring, plenum cable and raceways as specified in applicable section of Division 26. All control wiring, regardless of voltage, and necessary plenum cable, raceways and conduit, shall be provided by the controls contractor.

F. Power Line Surge Protection: Unit shall have solid state surge protection on phone, power and signal lines. Surge protection modules shall be replaceable.

G. Sensor and Control Wiring Surge Protection: Provide protective equipment that meets IEEE 472 surge withstand capacity test. Provide a separate metallic enclosure at ground potential for required equipment. Fuses not permitted for surge protection.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation: Perform installation under the supervision of competent technicians regularly employed in the installation of DDC systems. Provide pneumatic tubing, wiring, and conduit to connect the DDC components for an operational DDC system. Wiring and installation shall conform to NFPA 70.
   1. Identification: Label or code each field wire or pneumatic tube at each end as identified on approved shop drawings. Permanently label or code each point of field terminal strips to show the instrument or item served. Color coded cable with annotated cable diagrams may be used to accomplish cable identification.
   2. Temperature Sensors: Stabilize sensors to permit on the job installation that will require minimum field adjustment or calibration. Temperature sensor assemblies shall be readily accessible and adaptable to each type of application to allow quick, easy replacement and servicing without special tools or skills. Provide NEMA 4 enclosures for outdoor installations. Provide brushed aluminum or brushed stainless steel enclosures for sensors located in finished spaces.
   3. Pressure Sensors: Provide corrosion resistant sensors in NEMA 12 enclosures. Pressure sensing tip only shall be visible within a public space.
   4. Indicators: Mount temperature and pressure indicators to allow readability when standing at floor level; provide remote indicators where necessary.

B. Adjustments: Adjust controls and equipment to maintain the conditions indicated, to perform the functions indicated, and to operate in the sequence specified.

3.02 FIELD QUALITY CONTROL

A. Ensure that tests are performed or supervised by competent employees of the DDC system installer or the DDC system manufacturer regularly employed in the testing and calibration of DDC systems. If the Engineer witnesses tests, such tests shall be subject to approval. If the Engineer does not witness tests, provide performance certification. Perform field inspection and tests as stated in approved inspections and test plan.

1. Plan for Inspections and Tests: Furnish a written inspections and tests plan developed by the manufacturer of the DDC system at least 60 days prior to the field acceptance test date. The plan shall delineate the inspections and testing procedures required for all DDC components and systems to demonstrate compliance with the requirements specified in the paragraph titled "Field Acceptance Testing" of this section. Additionally, the test plan shall indicate how DDC system is to be tested, what variables will be monitored during test, names of individuals performing tests, and what criteria for acceptance should be used. Indicate how operation of HVAC system and DDC system in each seasonal condition will be simulated.
2. Field Acceptance Testing: Upon completion of 72 hours of continuous HVAC and DDC systems operation and before final acceptance of work, test the temperature control systems in service with the heating, ventilating, and air conditioning systems to demonstrate compliance with contract requirements. Notify the Engineer a minimum of ten working days prior to the date testing is to commence. Test controls and systems through each cycle of operation, including simulation of each season insofar as possible. Test each air compressor operation under full system load for compliance. Test safety controls to demonstrate performance of required function. Adjust or repair defective or malfunctioning DDC/ATC equipment or replace with new equipment. Repeat tests to demonstrate compliance with contract requirements.

3.03 SEQUENCE OF OPERATION

A. Sequence for new fan coil unit (FCU-7) and associated equipment (GV-1) shall be as follows:

1. Maintain space temperature at 68ºF heating and 75ºF cooling during occupied period, and 60ºF heating and 85ºF cooling during unoccupied hours.
2. Supply fan control: The fan runs continuously during occupied mode. During unoccupied mode, the fan shall cycle as required to maintain the zone temperature setpoint.
    a. During occupied mode, the gravity ventilator damper shall open to provide ventilation airflow. During unoccupied mode, the gravity ventilator damper shall be closed.
3. Cooling control (Occupied/Unoccupied Schedule): The chilled water control valve shall modulate to maintain the minimum zone temperature of 75ºF. When supply fan is off, the chilled water control valve shall be closed. The chilled water control valve shall be enabled whenever the outside air temperature is greater than 65ºF (adj), the supply fan is on, the

zone temperature sensor is calling for cooling, and the heating is not activated.

4. Heating control (Occupied/Unoccupied Schedule): The heating hot water control valve shall modulate to maintain the minimum zone temperature of 68ºF. When supply fan is off, the heating hot water control valve shall be closed. The chilled water control valve shall be enabled whenever the outside air temperature is greater than 60ºF (adj), the supply fan is on, the zone temperature sensor is calling for heating, and the heating is not activated. The heating hot water control valve shall modulate to 100% open whenever the freezestat is activated or the supply air temperature is less than 35ºF.
5. Filters: A filter maintenance differential pressure switch shall generate an alarm when pressure exceeds it adjustable setpoint.
6. Alarms: An alarm shall be generated upon the following conditions:
   a. Fan failure
   b. High or low supply air temperature
   c. Filter differential pressure exceeds high limit
   d. Freezestat status

B. Sequence for new Exhaust Fan (EF-1) shall be as follows:
   1. Whenever the zone is in occupied mode, the exhaust fan shall be enabled. During unoccupied mode, the exhaust fan shall be disabled.

3.04 INSTRUCTION OF OPERATING PERSONNEL

A. Upon completion of the work and at a time designated by the Engineer, furnish the services of a competent technician regularly employed by the temperature control manufacturer for the instruction of Owner personnel in the operation and maintenance of each DDC system. Provide hands on instruction using operating equipment provided. The period of instruction shall be for not less than one 8 hour working day.

END OF SECTION

SECTION 23 21 13
HYDRONIC PIPING AND SPECIALTIES

PART 1 - GENERAL

1.01 SUMMARY

A. Under this Section, the Contractor shall furnish all labor, materials and equipment for Hydronic Piping and Specialties as shown on the Plans, as specified, and/or directed.

B. Related Work specified elsewhere:
1. Section 23 05 00 – Mechanical General Requirements
2. Section 23 05 53 – Identification for HVAC Piping and Equipment
3. Section 23 05 93 – Testing and Balancing Air and Water Systems
4. Section 23 07 00 – HVAC Insulation
5. Section 23 81 26 – Unitary Air Conditioning Systems

1.02 REFERENCE STANDARDS

A. The following is a list of standards that may be referenced in this section:
1. American National Standards Institute, Inc. (ANSI) Publication:
   a. B1.1 – Unified Screw Threads
   b. B2.1 – Pipe Threads (Except Dryseal)
   c. B16.1 – Cast Iron Pipe Flanges and Flanged Fittings, 25, 125, 250, and 800 pound
   d. B16.3 – Malleable Iron Threaded Fittings
   e. B16.5 – Pipe Flanges and Flanged Fittings
   f. B16.9 – Factory Made Wrought Steel Butt Welding Fittings
   g. B16.11 – Forged Steel Fittings, Socket Welding and Threaded
   h. B16.18 – Cast Copper Alloy Solder Joint Pressure Fittings
   i. B16.22 – Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
   j. B16.24 – Bronze Pipe Flanges and Flanged Fittings
   k. B16.39 – Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300
   l. B18.2.2 – Square and Hex Nuts (Inch Series)
   m. B31.1 – Power Piping
   n. B40.100 – Pressure Gauges and Gauge Attachments
   o. B40.200 – Thermometers, Direct Reading and Remote Reading
   p. Z49.1 – Safety in Welding and Cutting
2. American Society for Testing and Materials (ASTM) Publication:
   a. A47 – Malleable Iron Castings
   b. A53 – Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded and Seamless
   c. A120 – Pipe, Steel, Black and Hot Dipped Zinc Coated (Galvanized) Welded and Seamless for Ordinary Uses
   d. A183 – Heat Treated Carbon Steel Track Bolts and Carbon Steel Nuts

e. A194/A194M – Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service
f. A307 – Carbon Steel Externally and Internally Threaded Standard Fasteners
g. A386 – Zinc Coating (Hot Dip) on Assembled Steel Products
h. A525 – Sheet Steel, Zinc-Coated (Galvanized) by the Hot-Dip Process
i. A536 – Ductile Iron Castings
j. B32 – Solder Metal
k. B75 – Seamless Copper Tube
l. B88 – Seamless Copper Water Tube
m. B111 – Copper and Copper Alloy Seamless Condenser Tubes and Ferrule Stock
n. B395 – U Bend Seamless Copper and Copper Alloy Heat Exchanger and Condenser Tubes
o. D2000 – Rubber Products in Automotive Applications

3. American Society of Mechanical Engineers (ASME) Publication:
   a. BPV – Boiler and Pressure Vessel Code and Interpretations
   b. BPVSEC4 – Heating Boilers
   c. BPVSEC8 – Pressure Vessels (Division 1)
   d. PTC4.1 – Steam Generating Units
4. Copper Development Association, Inc. (CDA) Publication:
   a. 404/1 – Copper Tube Handbook
5. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Publications:
   a. SP58 – Pipe Hangers and Supports Materials, Design, and Manufacture
   b. SP67 – Butterfly Valves
   c. SP69 – Pipe Hangers and Supports Selection and Application
   d. SP70 – Cast Iron Gate Valves, Flanged and Threaded Ends
   e. SP80 – Bronze Gate, Globe, Angle and Check Valves
   f. SP83 – Carbon Steel Pipe Unions Socket Welding and Threaded
6. Uniform Fire Prevention and Building Code of New York State Publication:
   a. 2020 Mechanical Code

1.03 SUBMITTALS

A. Detail Drawings: Shop Drawings and Catalog Cuts: Submit shop drawings and catalog information showing plan, elevations, dimensions, capacities, and ratings for the following:
1. Piping and fittings
2. Valves
3. Hangers and Supports
4. Flexible connectors
5. Glycol Fill Station and Glycol
6. Convector Unit

B. Certificates of Compliance:
   1. Manufacturer's Certificate: Submit manufacturer's certificate of boiler performance and a Certificate of Full Approval or a current Certificate of Approval for backflow preventers.

C. Welding Submittals: As required by ANSI B31.9 and ANSI B31.5.

1.04 GENERAL REQUIREMENTS

A. Classes and Maximum Working Pressures: Except as specified otherwise, equipment and piping components shall be suitable for use under the maximum working pressures indicated. Except as modified herein, the pressure temperature limitations shall be as specified in the referenced standards and specifications. All pressures in this specification are pressures in pounds per square inch (psi) above atmospheric pressure, and all temperatures are in degrees Fahrenheit (F).

B. Safety Standards:
   1. Welding: Safety in welding and cutting of pipe shall conform to ANSI Z49.1.
   2. Guards: Couplings, motor shafts, gears and other moving parts shall be fully guarded, in accordance with OSHA 29 CFR 1910.219. Guards shall be cast iron or expanded metal. Guard parts shall be rigid and suitably secured and be readily removable without disassembling the guarded unit.

1.05 WELDING REQUIREMENTS

A. Welding Procedure: Before any welding is performed, the Contractor shall submit to the Owner's Representative three copies of welding procedure specification for all metals included in the work, together with proof of its qualifications in accordance with ANSI B31.9 and ANSI B31.5.

B. Performance Qualification Record: Before any welder or operator performs any welding, the Contractor shall also submit to the Owner's Representative three copies of the Welder's Performance Qualification Record in conformance with ANSI B31.9 and ANSI B31.5 showing that the welder was tested under the approved procedure specification submitted by the Contractor. In addition, the Contractor shall submit the assigned number, letter, or symbol used to identify the work of the welder, and affix it immediately upon completion of the weld. Give welders making defective welds, after passing a qualification test, a requalification test, and do not permit them to work under this Contract if they fail the requalification test.

C. Previous Qualifications: Welding procedures, welders, and welding operators previously qualified by test may be accepted for this Contract without requalifying subject to the approval of the Owner's Representative and provided that all the conditions specified in ANSI B31.9 and ANSI B31.5 are met before a procedure is used.

PART 2 - PRODUCTS

2.01 PIPE AND FITTINGS

A. Low Pressure Piping System: Requirements specified herein working pressure of 30 psi or less.
   1. Hot Water Heating, Chilled Water, and Condensate Drain Pipe (Supply and Return): ASTM B88 Type L Copper tubing. Use ASTM A53 pipe for bending.

B. Fittings: Fittings shall be comparable thickness with the pipe being used, and shall conform to the following requirements.
   1. Fittings for Copper Tubing 2-1/2 Inches and Smaller: ANSI B16.18 cast bronze solder joint type or ANSI B16.22 wrought copper solder joint type. Fittings may also be flared or compression joint type.

C. End Connections:
   1. Copper Tubing:
      a. ASTM B32, Grade Sb5, tin-antimony alloy. Soldering flux shall consist of petrolatum base impregnated with zinc and ammonium chlorides.

D. Unions:
   1. Steel Pipe: ANSI B16.3, threaded.
   2. Copper Tubing: ANSI B16.18 solder joint end.
   3. Dielectric Union: Insulated union provided with a galvanized steel female pipe threaded end and a copper solder joint end conforming with FS WW U 531, Class 1, dimensional, strength and pressure requirements. Union shall have a water impervious insulation barrier capable of limiting galvanic current to one percent of the short circuit current in a corresponding bimetallic joint. When dry, insulation barrier shall be able to withstand a 600 volt breakdown test.

E. Flanges: Removed raised faces when used with flanges having a flat face.
   1. Steel Flanges: ANSI B16.5 forged steel, welding type.
   2. Cast Iron Screwed Flanges: ANSI B16.1.
   3. Bronze Screwed Flanges: ANSI B16.24.

F. Flexible Connectors:
   1. Class 150, flexible metal connector, stainless steel annular hose with stainless steel braid. End fittings shall be ANSI Class 150 raised face carbon steel flanges. Inner convoluted hose shall be Type 304 stainless steel and exterior sleeve shall be braided Type 304 stainless steel. Nominal pipe size 1-1/2” to 5” shall have minimum overall length of 12”. Nominal pipe size 6” to 10” shall have minimum overall length of 18”. Nominal pipe size over 12” shall have minimum overall length of 24”. Minimum rated pressure shall be 150 PSIG, provide double braided hose as required to achieve pressure rating. Maximum lateral offset shall be no less than 1/4". Manufacture shall be as by Mason Industries, or approved equal.

G. Instrumentation:

1. Pressure and Vacuum Gauges: ANSI B40.100 with restrictor, located as indicated. Furnish pressure gauges with black phenol cases constructed of glass filled polypropylene. Gauge face shall have a diameter of 4-1/2 inches. Gauges shall be stem mounted with phosphor bronze bourdon tubes. Manufacture shall be as by Ashcroft (Model 1279), or approved equal. Furnish with 1/4 turn, ball type bronze isolation valve and pigtail siphon. Pressure range shall be 0-150 psig.
2. Indicating Thermometers: ANSI B40.200, liquid-in-glass red or blue column, clear plastic window, with 6-inch brass stem, vertical scale immersion type furnished with brass well, adjustable angle, scale not less than 9 inches with a range of 30ºF to 240ºF for hot water systems and 20ºF to 180ºF for chilled or condenser water systems. Temperature ranges to be approved prior to order or installation. Manufacture shall be as by Weksler Instruments, or approved equal.
3. Thermowell: ANSI B40.200, reduced tip stainless steel thermowells to accept the temperature sensing devices. Immersion length shall be as required and connections shall be 3/4-inch NPT. Manufacture shall be as by Weksler Instruments, Ashcroft, or approved equal.

H. Miscellaneous Pipeline Components:

1. Air Vent: Float type to vent air in hydronic systems. Vent to be constructed of noncorrosive materials and to have NPT male inlet and compression connector for 1/4 inch overflow for safe water connection.
2. Strainers (2 Inches and Smaller): Strainers shall be Y-pattern type, bronze body, screwed, Class 150, with 20 mesh Monel screen. Provide all strainers with bronze blow-down valve. Manufacture shall be as by Watts, Nibco, or approved equal.
3. Strainers (2-1/2 Inches and Larger): Strainers shall be Y-pattern type, cast iron body, flanged, Class 250 with 20 mesh Monel screen. Provide all strainers with bronze blow-down valve. Manufacture shall be as by Watts, Nibco, or approved equal.
4. Basket Strainers: Strainers shall be the ANSI 125 pound, iron body flanged basket type, self-cleaning with angular cutaway brass basket (60 mesh), and large open area to minimize pressure loss. Manufacture shall be as by Watts, Keckley, Eaton, or approved equal.

2.02 VALVES

A. Valves shall have rising stems and shall open when turned counterclockwise.

B. Gate Valves:

1. Bronze Gate Valves: Two inches and smaller. Wedge disc, rising stem, inside screw type not less than 150-pound class. Use solder joint ends with copper tubing conforming to ANSI B16.18.
2. Cast Iron Gate Valves: 2 1/2 inches and larger. ASTM A125, Class B cast iron, flanged, Class 150, OS&Y with rising stem, bolted bonnet and ASTM B62 bronze disc and seat.

C. Ball Valves:
   1. Ball Valves: Three inches and smaller. 600 psi CWP, cast bronze bodies, Class 150, two-position hand levers, full port, replaceable reinforced Teflon seats, blow-out proof stem with chrome-plated ball and threaded ends. Manufacture shall be as by Nibco, Apollo, or approved equal.

D. Globe and Angle Valves:
   1. Bronze Globe and Angle Valves: 2 inches and smaller. ASTM B62 bronze, screwed, Class 150, union bonnet, with renewable ASTM A276, Type 420 stainless steel seat and disc and threaded ends. Manufacture shall be as by Nibco, Powell, or approved equal.
   2. Cast Iron Globe and Angle Valves: 2 1/2 inches and larger. ASTM A125, Class B cast iron, flanged, Class 150, with bronze trim, tapped drains and brass plug. Manufacture shall be as by Nibco, Powell, or approved equal.

E. Check Valves:
   1. Check Valve 2-1/2 Inches and Smaller: Swing type check valves shall be ASTM B62 bronze body, threaded, Class 125, threaded cap with bronze trim. Manufacture shall be as by Nibco, Watts, or approved equal.
   2. Check Valve 3-Inches and Larger: Swing type check valves shall be ASTM A-126, Class B cast iron body flanged, Class 150, bolted cap with bronze trim. Manufacture shall be as by Nibco, Watts, or approved equal.
   3. Disc Check Valve: Dual disc type, spring actuated with grooved end ductile iron body, bronze discs, stainless steel stem and springs, and resilient disc seats. Disc check valves shall be as manufactured by Victaulic Series 711, or equal.
   4. Wafer Check Split Disc Valves: Valves shall be high-performance, dual plate, flat seat and independent springs. Body shall be cast iron with aluminum bronze discs, Buna N seals, wafer body suitable for mounting between ANSI 125 pound flanges. Manufacture shall be as by Flomatic (Model 895), Crane, or approved equal.

F. Butterfly Valves:
   1. Butterfly Valves (2 Inches and Larger): The valves shall conform with MSS SP67, Type I Tight shut off valve, and valve ends shall be Flanged. The valve body material shall be bronze and shall be bubble tight for shutoff at 150 psig. Flanged and flangeless type valves shall have Type 300 series corrosion resistant steel stems and corrosion resistant or bronze discs with molded elastomer disc seals. Flow conditions shall be for the regulation from maximum flow to complete shutoff by way of throttling effect. Valves shall be used in closed system. Valves smaller than 8 inches shall have throttling handles. Valves 8 inches and larger shall have totally enclosed manual gear operators with adjustable balance return stops and indicators. Valves shall have a minimum of 7 locking positions and shall be suitable for water temperatures up to 200ºF. Manufacture shall be as by Nibco, Watts, Anvil, or approved equal.

G. Balancing Valves:

1. Balancing Valves (3 Inches and Smaller): Brass construction with 304 stainless steel ball, Teflon seats and two (2) ¼-inch differential pressure read-out ports. Valves shall be provided with calibrated nameplates and memory stops. Valves shall be manufactured by Bell & Gossett Circuit Setter Plus, or approved equal.
2. Balancing Valves (4 Inches and Larger): Cast iron, flanged rated for 175 psig working pressure, or ductile iron grooved, rated for 300 psig, multi-turn globe style, brass disc, EPDM soft seat, and two pressure/temperature ports. Valve shall utilize a calibrated nameplate with position indicator from 0 to 100% open and memory button. Valves shall be manufactured by Bell & Gossett Circuit Setter Plus, or approved equal.

2.03 PIPE, VALVES AND EQUIPMENT INSULATION AND IDENTIFICATION

A. Section 23 05 53, “Identification for HVAC Piping and Equipment”.

B. Section 23 07 00, “HVAC Insulation”.

2.04 PROPYLENE GLYCOL

A. Provide 30% propylene glycol mixture with water for circulating chilled water fluid.

2.05 PROPYLENE GLYCOL FILL STATION

A. Factory fabricated, automatic and autonomous make-up glycol system package, consisting of a pressurization assembly mounted on a translucent polyethylene 6-gallon solution container complete with cover. System shall be designed to operate at a maximum temperature of 130ºF with a factory discharge pressure setting of 12 PSIG. Pressurization assembly shall include pressurization pump with pressure controls, a pressure reducing valve, and pressure gauge. The pressurization pump shall operate on an 110V, 60 Hz motor and maintain fill pressure in the glycol system.

2.06 CONVECTOR UNIT

A. Powder paint coated, 18-gauge cold rolled steel enclosure, completely exposed wall hung type with flat top, wrap around sides, mounting clips, open bottom and outlet grille in the face of the enclosure. Front grille shall have a damper operator in face. Convector heating element consists of aluminum fins mechanically bonded to 3/8-inch diameter copper tubes. Tubes are joined at each end by cast brass ¾-inch headers with ¼-inch tappings for venting. Headers shall be provided for bottom pipe connection on inlet and outlet. Manufacture shall be as by Sterling Model W-A, or approved equal.

1. Thermostatic Radiator Valve Assembly: two-part assembly consisting of the brass valve body and thermostatic operator. Brass valve body shall have a packing gland assembly capable of replacement while system is in operation. Valve shall be a straight configuration with EPDM rubber valve disc, and tested at a maximum temperature of 250ºF and maximum test pressure of 232 psi. Thermostatic operator shall have manual plastic cap

with adjustable dial and numbered scale of 1 to 5 corresponding to temperatures of 57ºto 79ºF. Operator shall be supplied with a remote temperature sensor to be mounted on enclosure as indicated. Manufacture shall be as by Danfoss Model RA 2000, or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Piping: Unless specifically stated to the contrary, fabrication, assembly, welding, soldering, and brazing shall conform to ANSI B31.1 for all piping of the hot water system and ANSI B31.9 for chilled and condenser water systems. Provide drain valves at low points of piping system, and air vent valves at high points where air pockets would occur. All piping shall follow the general arrangement shown; cut accurately to measurements established for the work by the Contractor, and work into place without springing or forcing, except where cold springing is specified. Install piping and equipment within buildings entirely out of the way of lighting fixtures and doors, windows, and other openings. Run overhead piping in buildings in the most inconspicuous positions. Provide adequate clearances from walls, ceilings, and floors to permit the welding of joints; at least 6 inches for pipe sizes 4 inches and less, 10 inches for pipe sizes over 4 inches, and in corners provide sufficient clearance to permit the welder to work between the pipe and one wall. Make provision for expansion and contraction of pipelines. Make changes in size of waterlines with reducing fittings. Do not bury, conceal, or insulate piping until it has been inspected, tested, and approved. Protect materials and equipment from the weather. Do not run piping concealed in walls or partitions or underground or under the floor except as otherwise indicated. Where pipe passes through building structure, do not conceal pipe joints but locate where they may be readily inspected. Run all pipe to be insulated as shown and as required with sufficient clearance to permit application of insulation. Use flanged joints only where necessary for normal maintenance and where required to match valves and equipment. Provide gaskets, packing, and thread compounds suitable for the service. Use long radius ells wherever possible to reduce pressure drops. Pipe bends in lieu of welding fittings may be used where space permits. Pipe bends shall have a uniform radius of at least five times the pipe diameter and must be free from any appreciable flattening, wrinkling, or thinning of the pipe. Do not use mitering of pipe to form elbows, notching straight runs to form full sized tees, or any similar construction. Make all branch connections with welding tees except factory made forged welding branch outlets or nozzles having integral reinforcements conforming to ANSI B31.1 may be used, provided the nominal diameter of the branch is at least one pipe size less than the nominal diameter of the run. Run all piping essentially as indicated, taking care to avoid interference with other piping, conduit, or equipment. Except where specifically shown otherwise, vertical piping shall run plumb and straight and parallel to walls. Trapping of lines is not permitted except as otherwise indicated. Provide sleeves of suitable size for all lines passing through building structure. Install piping connected to equipment to provide flexibility for thermal stresses and for vibration, and adequately support and anchor so that strain from weight and thermal movement of piping is not imposed on the equipment.

1. Welding:
   a. Welding Procedure Specifications: Before any welding is performed, the Contractor shall submit three copies of his welding procedure specification for all metals included in the work, together with proof of its qualification as outlined in ANSI B31.1.
   b. Performance Qualification Record: Before any welder or operator performs any welding, submit three copies of Welder's Performance Qualification Record in conformance with ANSI B31.1 showing that the welder was tested under the approved procedure specification submitted by the Contractor. In addition, submit each welder's assigned number, letter, or symbol used to identify the work of the welder, and affix immediately upon completion of the weld. To welders making defective welds after passing a qualification test give a requalification test and upon failing to pass the test do not permit to work this contract.
   c. Previous Qualifications: Welding procedures, welders, and welding operators previously qualified by test may be accepted for this contract without requalification subject to the approval and provided that all the conditions specified in ANSI B31.1 are met before a procedure can be used.
2. Brazing and Soldering:
   a. Brazing and Soldering Procedure Qualifications: Brazing and soldering procedure qualifications shall conform to ANSI B31.1. Brazing procedure for joints shall be as outlined in CDA 404/1, the Copper Tube Handbook, published by the Copper Development Association.
   b. Soldering Preparation and Procedures: Soldering, soldering preparation, and procedures for joints shall be in accordance with ANSI B31.1 and as outlined in CDA 404/1, the Copper Tube Handbook, published by the Copper Development Association.
3. Hangers and Supports: The design and fabrication of pipe hangers, supports, and welding attachments shall conform to MSS SP58 and ANSI B31.1. Hanger types and supports for bare and covered pipe shall conform to MSS SP69 for the temperature range. Unless otherwise indicated, horizontal and vertical piping attachments shall conform to MSS SP58. Continuous inserts and expansion bolts may be used.
   a. Maximum Spacing Between Supports:
      1) Vertical Piping: Support metal piping at not more than 10-foot intervals.
      2) Horizontal Piping: Support cast-iron piping at 5-foot intervals, except for pipe exceeding 5-foot length, provide supports at intervals equal to the pipe length but not exceeding 10 feet. Support piping and copper tubing as follows, unless indicated otherwise:

MAXIMUM SPACING (FEET)						
Nominal Pipe Size (Inches)	One and Under	1.25	1.5	2	2.5	3 and Over
Steel Pipe	7	8	9	10	11	12
Copper Tube	6	6	7	7	8	8

4. Grading of Pipelines: Unless otherwise indicated, install horizontal lines of hot water piping to grade down in the direction of flow with a pitch of not less than one inch in 30 feet, except in loop mains and main headers where the flow may be in either direction.
5. Pipe Sleeves: Provide sleeves where pipes and tubing pass through masonry or concrete walls, floors, roof, and partitions. Sleeves in outside walls below and above grade, in floor, or in roof slabs, shall be steel pipe. Sleeves in partitions shall be zinc coated sheet steel having a nominal weight of not less than 0.906 pound per square foot. Space between pipe, tubing, or insulation and the sleeve shall be not less than 1/4 inch. Hold sleeves securely in proper position and location before and during construction. All sleeves shall be of sufficient length to pass through entire thickness of walls, partitions, or slabs. Sleeves in floor slabs shall extend 2 inches above the finished floor. Firmly pack space between the pipe or tubing and the sleeve with oakum and calk on both ends of the sleeve with elastic cement.
6. Floor, Wall, and Ceiling Escutcheon Plates: Secure sleeves in buildings other than power and heating plants, to the pipe. Plates on pipes passing through floors and partitions of toilet rooms shall be chromium plated steel or nickel plated cast iron; all other plates shall be painted cast iron, malleable iron, or steel.
7. Flashing for Buildings: Provide flashing where pipes pass through building roofs, and make outside walls tight and waterproof.
8. Unions and Flanges: Provide unions and flanges where necessary to permit easy disconnection of piping and apparatus and as indicated. Each connection having a screwed end valve shall have a union. Place unions and flanges as indicated. Use unions on piping under 2 inches in diameter, and use flanges on piping 2 inches and over in diameter. Provide dielectric unions or flanges between ferrous and nonferrous piping, equipment, and fittings; except that bronze valves and fittings may be used without dielectric couplings for ferrous to ferrous or nonferrous to nonferrous connections. Dielectric fittings shall utilize a nonmetallic filler which will prevent current flow from exceeding one percent of the short circuit current. The spacer shall be suitable for the pressure and temperature of the service. . Flanges and unions shall conform to the requirements of ANSI B16.10.
9. Changes in Pipe Size: Use reducing fittings for changes in pipe size; the use of bushings is not to be permitted. In horizontal lines, use reducing fittings of the eccentric type to maintain the top of the lines in the same plane.

10. Cleaning of Pipe: Thoroughly clean each section of pipe, fittings, and valves positively free of all foreign matter before erection. Prior to erection, hold each piece of pipe in an inclined position and thoroughly tap along its full length to loosen sand, mill scale and other foreign matter. Pipe 2 inches and larger shall have a wire brush of a diameter larger than that of the inside of the pipe drawn through its entire length several times. Before final connections are made to apparatus, wash out the interior of all piping thoroughly with water. Plug or cap open ends of mains during all shutdown periods. Do not leave lines open at any place where any foreign matter might accidentally enter pipe.

B. Valves:
   1. General: Install valves in conformance with ANSI B31.1, ASME BPVSEC4 of the Boiler and Pressure Vessel Code, and as required herein at the locations indicated and elsewhere as required for the proper functioning of the system. Remove valve bonnets, where valve construction permits removal, when connecting valves by brazing to copper tubing. Install all valves with stems horizontal or above. Provide unions on one side of all valves to facilitate servicing. Locate or equip stop valves to permit operation from floor level, or provide with safe access in the form of walkways or ladders. Install valves in positions accessible for operation and repair.
   2. Globe Valves: Install globe valves so that the pressure is below the disk and the stem horizontal.

C. Pressure Gage: Provide a shut off valve or pet cock between pressure gages and the line.

D. Thermometers: Provide thermometers and thermal sensing elements of control valves, etc., with a separable socket. Install separable sockets in pipelines in such a manner to sense the flowing temperature of the fluid and minimize obstruction to flow.

E. Strainers: Provide strainers with meshes suitable for the services where indicated, or where dirt might interfere with the proper operation of valve parts, orifices, or moving parts of equipment.

F. Connections to Existing Services: Provide connections, splices, and branches at the locations shown. When new fittings are installed into an existing pipeline for the purpose of a branch or splice, the new fittings shall be of the same diameter as the existing pipeline. New branch lines off existing pipelines may be of reduced diameter.

3.02 PROPYLENE GLYCOL AND FILL STATION

A. The Contractor shall provide all labor, materials, equipment, supervision, and specialties necessary for installation of the glycol fill station. Install system and accessories in accordance with manufacturer’s installation instructions and the Contract Documents. Contractor shall completely drain the existing chilled water/glycol system, including all equipment, chiller and chilled water coils throughout the facility, and properly dispose of existing chilled water/glycol fluid.

Replace the existing fluid with 30% propylene glycol and water mixture, refilling the existing equipment, chiller and chiller water coils, and purge air from the piping system. Contractor to start up and initially operate the existing chilled water system, including chiller, pumps, coils and associated equipment, with all components operating. Inspect and check all fittings and connections for any leaks or system malfunctions.

3.03 CONVECTOR UNIT

A. The Contractor shall provide all labor, materials, equipment, supervision, and specialties necessary for installation of the wall-mounted convector units in accordance with manufacturer's installation instructions and the Contract Documents. Contractor to start up and initially operate the convector units, with all components operating. Inspect and check all fittings and connections for any leaks or system malfunctions.

3.04 CLEANING, PAINTING AND IDENTIFICATION

A. Clean and paint piping in accordance with Section 09 91 23, "Interior Painting".

B. Exposed piping shall be painted for the purpose of color coding in accordance with the identification code currently in use. Identify all piping in accordance with Section 23 05 53,"Identification for HVAC Piping and Equipment".

3.05 TESTING

A. General: The Contractor is responsible for the performance of all inspections and tests as specified herein to demonstrate that the piping system, as installed, is in compliance with contract requirements. During testing, clean the various strainers until no further accumulation of foreign material occurs. Exercise care so that minimum loss of water occurs when strainers are cleaned. In accordance with the General Provisions, the Owner will furnish water and electricity.

B. Piping System: Test piping system hydrostatically using water not exceeding 100ºF. Conduct tests in accordance with the requirements of ANSI B31.1 and as follows. Test the piping system after the lines have been cleaned as herein specified and before insulation covering has been applied. Tests piping systems at a pressure of 30 psig. In all tests remove or valve off from the system, gages, and other apparatus which maybe damaged by the test before the tests are made. Repair leaks. Do not caulk joints. Install calibrated test pressure gage in the system to observe any loss in pressure. Maintain the required test pressure for a sufficient length of time to enable an inspection to be made of all joints and connections. Perform tests after installation and prior to acceptance.

END OF SECTION

SECTION 23 23 13
REFRIGERANT PIPING & SPECIALTIES

PART 1 - GENERAL

1.01 SUMMARY

A. Under this Section, the Contractor shall furnish all labor, materials and equipment for Refrigerant Piping & Specialties as shown on the Plans, as specified and/or directed.

B. Related Work specified elsewhere:
1. Section 23 05 00 – Mechanical General Requirements
2. Section 23 05 53 – Identification for HVAC Piping and Equipment
3. Section 23 05 93 – Testing and Balancing Air and Water Systems
4. Section 23 07 00 – HVAC Insulation
5. Section 23 81 26 – Unitary Air Conditioning Systems

1.02 REFERENCE STANDARDS

A. The following is a list of standards that may be referenced in this section:
1. American National Standards Institute, Inc. (ANSI) Publication:
   a. B16.10 – Face to Face and End to End Dimensions of Ferrous Valves
   b. B16.22 – Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
   c. B31.5 – Refrigeration Piping
   d. B31.9 – Building Services Piping
   e. B40.100 – Pressure Gauges and Gauge Attachments
   f. B40.200 – Thermometers, Direct Reading and Remote Reading
2. Air Conditioning, Heating and Refrigeration Institute (AHRI) Publication:
   a. 710 – Liquid-Line Driers
   b. 715 – Liquid-Line Filters
   c. 730 – Suction-Line Filters and Filter-Driers
   d. 750 – Thermostatic Refrigerant Expansion Valves
   e. 760 – Solenoid Valves for Use with Volatile Refrigerants
   f. 770 – Refrigerant Pressure Regulating Valves
3. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE) Publication:
   a. 15 – Safety Standard for Refrigeration Systems
   b. 17 – Thermostatic Refrigerant Expansion Valves, Method of Testing
   c. 34 – Designation and Classification of Refrigerants
   d. 63 – Liquid Line Refrigerant Driers, Method of Testing
   e. 78 – Suction Line Filters and Driers, Method of Testing
   f. 158 – Refrigerant Solenoid Valves, Method of Testing

4. American Society for Testing and Materials (ASTM) Publication:
   a. B32 – Solder Metal
   b. B88 – Seamless Copper Water Tube
   c. B280 – Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
5. American Welding Society, Inc. (AWS) Publication:
   a. A5.8 – Brazing Filler Metal
6. The Copper Development Association, Inc., Publication:
   a. Copper Tube Handbook
7. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Publication:
   a. SP58 – Pipe Hangers and Supports Materials, Design, and Manufacture
   b. SP69 – Pipe Hangers and Supports Selection and Application
   c. SP70 – Cast Iron Gate Valves, Flanged and Threaded Ends
   d. SP80 – Bronze Gate, Globe, Angle and Check Valves
   e. SP83 – Carbon Steel Pipe Unions Socket Welding and Threaded
8. Underwriter's Laboratory (UL) Publication:
   a. 109 – Tube Fittings for Flammable and Combustible Fluids, Refrigerants and Marine Use
   b. 207 – Refrigerant-Containing Components and Accessories
   c. 429 – Electrically Operated Valves
   d. 2182 – Standard for Refrigerants
9. Uniform Fire Prevention and Building Code of New York State Publication:
   a. 2020 Mechanical Code
   b. 2020 Energy Conservation Construction Code

1.03 SUBMITTALS

A. Manufacturer's Data:
   1. Piping and Fittings
   2. Gaskets
   3. Valves
   4. Piping Accessories
   5. Hangers and Supports
   6. Sight Glass
   7. Filter Driers
   8. Control Valves and Accessories
   9. Pressure Gauges
   10. Strainers
   11. Thermal Expansion Valves
   12. Thermometers

1.04 SAFETY PRECAUTIONS:

A. Refrigerant Piping Safety: ANSI 15.
   1. Refrigerant Handling: Follow safety regulations and refrigerant manufacturer's instructions to prevent hazardous exposure to personnel.
   2. Rotating Equipment Safety: Fully guard couplings, motor shafts, gears and other exposed rotating or rapidly moving parts in accordance with

ASME B15.1. The guards shall be cast iron or expanded metal. Guard parts shall be rigid, secured, and readily removable without disassembling the guarded unit.

PART 2 - PRODUCTS

2.01 REFRIGERANT PIPING, FITTINGS, AND ACCESSORIES:

A. Refrigerant Piping: Dimensions and material requirements for pipe, pipe fittings and components shall conform to ANSI 15 and ANSI B31.5 and shall be compatible with fluids used and capable of withstanding the pressures and temperatures of the service. Tubing used for refrigerant service shall be cleaned, sealed, capped, or plugged prior to shipment from the manufacturer's plant.

1. Field Assembled Piping - Copper Pipe and Fittings: Seamless copper tubing, hard drawn, Type K or L for exposed above ground use, ASTM B88. Fittings for copper tubing shall be wrought copper, brazing, or solder joint type, ANSI B16.22. Soft annealed copper tubing conforming to ASTM B280 may be used where flare connections to equipment are required only in nominal sizes less than 1 inch.
2. Factory Charged Tubing - Tubing shall be extra soft, deoxidized, bright annealed copper conforming to ASTM B280, factory dehydrated and furnished with a balanced charge of refrigerant recommended by the manufacturer of equipment being connected. The tubing shall contain quick-connectors with caps or plugs to protect couplings. Include couplings for suction and liquid line connections of the indoor and outdoor sections.
3. Joints: Joints shall be brazed, flared or flanged (ANSI 150 lb Steel).
4. Fittings: ANSI 16.22 for solder-joint fittings. UL 109 for flared tube fittings.
5. Brazing Materials: AWS 5.8 brazing filler metal type BAg 5 with AWS Type 3 flux, except type BCuP 5 or BCuP 6 may be used for brazing copper-to copper joints.
6. Soldering Materials: ASTM B32, Grade Sb5, tin antimony alloy. Soldering flux shall consist of petrolatum base impregnated with zinc and ammonium chlorides.

B. Gaskets: ASTM D2000, fluorinated elastomers compatible in form with grooves in the flange faces.

C. Valves:

1. Ball Valves 1/2 Inch Through 2-5/8 Inches (ODS): Furnish UL listed, full port ball valves, forged brass body, stainless steel stock plate, brass ball with internal relief port, bi-directional, suitable for use with refrigerant type (as required) over a temperature range from -40ºF to 300ºF and a maximum operating pressure of 700 psig. Furnish with forged brass body solder ends and mechanical stop to ensure positive open or closed position. Seals shall be dual at each end constructed of Teflon. Manufacture shall be as by Sporlan EBV Series, or approved equal.
2. Thermal Expansion Valves (TXV): Furnish thermal expansion valves for refrigerant type as scheduled on the Contract Drawings. Expansion valves shall have replaceable, interchangeable components and external

superheat adjustment. Cages shall be interchangeable. Valves shall be as manufactured by Alco Controls, Series T, or approved equal.

3. Refrigerant Solenoid Valves: Provide two-way normally closed diaphram valves, U.L. listed, suitable for use with refrigerant type (as required). Valves shall be provided with copper extension tubes sized as required. All valves shall have full ID port size with maximum operating pressure of 300 psi, and operable in any position. Valve control voltage shall be 120V AC. Manufacturer shall be as by Emerson Climate Technologies, Model 240RA, or approved equal.

D. Sight Glass: Furnish a moisture-liquid indicator with removable cartridge that changes color when wet to indicate moisture. Furnish line size with solder ends suitable for use with refrigerant type (as required). Manufacture shall be as by Emerson Climate Technologies (Type AMI-1SS), or approved equal.

E. Liquid Filter-Drier: Furnish steel shell filter-drier with forged tongue-and-groove flanged end suitable for use with refrigerant type (as required) and maximum rated pressure of 650 psig. Core shall be replaceable type. Manufacture shall be as by Sporlan Valve Company (Catch-All Type C, RC-4864 core), or approved equal.

F. Suction Filter-Drier: Furnish steel shell filter-drier with forged tongue-and-groove flanged end suitable for use with refrigerant type (as required). Provide each filter dryer with an activated core element and a felt type element. Manufacture shall by as by Sporlan Valve Co. (Catch-All Type C, RC-4864 activated core element, RFE-48-BD felt element), or approved equal.

G. Flexible Connector: Provide braided bronze-wire construction with corrugated phosphorus bronze annular hose and copper tube solder ends. Connectors shall be line sized with a maximum working pressure of 340 psig (liquid lines) or 245 psig (suction lines). Manufacture shall be as by Superior Valve Company, or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install piping and piping components to ensure proper and efficient operation of the equipment and controls and in accordance with manufacturer's printed instructions. Provide proper supports for the mounting of vibration isolators, stands, guides, anchors, clamps and brackets. Arrange piping connections to equipment so that removal of equipment or components of equipment including tube withdrawal from chillers, pump casing, shaft seals and similar work can be accomplished with the least amount of disassembly or removal of the piping system. Provide piping connected to equipment with vibration isolators with flexible connections which shall conform to vibration and sound isolation requirements for the system. Electric isolation shall be provided between dissimilar metals to reduce the rate of galvanic corrosion.

1. Refrigeration Piping: ANSI B15 and ANSI B31.5.

3.02 PIPING SYSTEMS:

A. Cut to the measurements established at the site and work into place without springing or forcing. Install piping with line flexibility included to absorb the expansion and contraction due to temperature changes of the piping systems. Piping line flexibility shall be achieved by the use of pipe bends or loops.

B. Flanged Joints: Faced true, square, tight and used as indicated and where necessary for normal maintenance. Mate with valves and the various equipment connections. Remove the raised faces when used with flanges having a flat face.

C. Pipe Bends: Acceptable in lieu of pipe fittings where space permits. The pipe bends shall have a uniform radius of at least five times the nominal pipe diameter. The pipe bends shall be free of any flattening, wrinkling, or thinning of the pipe walls other than minor external surface distortions. In occupied space, pipe bend radii shall not exceed five times the nominal pipe diameter.
   1. Pipe bends for annealed copper tubing in lieu of fittings may be used where space permits. The bends for annealed copper tubing shall conform to "Copper Tube Handbook" published by the Copper Development Association, Inc. The tubing bends shall be free of any appreciable flattening, wrinkling, or thinning of the tubing walls.

D. Reducing Fittings: Use to connect changes of sizes in piping lines. Make branch connections with tees except that factory made, forged steel welding branch outlets or nozzles having integral reinforcements and conforming to ANSI B31.9 may be used if the nominal diameter of the piping system branch does not exceed one nominal pipe size less than the nominal size of the piping segment containing the fitting. Reducer bushing shall not be used.

E. Insulation: Piping insulation shall be in accordance with Section 23 07 00, "HVAC Insulation", with enough clearance allowed between pipes to permit application of the insulation.

F. Brazing and Soldering:
   1. Brazing and Brazing Procedure Qualification for refrigerant piping systems shall conform to ANSI B31.5. Brazing procedure for joints shall be in accordance with the procedure as outlined in the "Copper Tube Handbook" published by the Copper Development Association, Inc., except that during the brazing operation the tubing shall be protected from forming an oxide film on the inside of the tubing by slowly flowing dry nitrogen to expel the air.
   2. Soldering: The preparation and procedures for the soldering of joints shall conform to ANSI B31.9 and ANSI B31.5 and shall be in accordance with the procedure as outlined in the "Copper Tube Handbook" published by the Copper Development Association, Inc.

G. Dielectric Unions or Flanges: Provide between ferrous and nonferrous piping, equipment, and fittings; except that bronze valves and fittings may be used without dielectric couplings for ferrous to ferrous or nonferrous to-nonferrous

connections. Flanges and unions shall conform to the requirements of ANSI B16.10.

H. Pipe Hangers and Supports: Where not shown, design and fabrication of pipe hangers, supports, and welding attachments shall conform to MSS SP 58. Hanger types and supports for bare and covered pipes shall conform to MSS SP 69 for the system temperature range. Unless otherwise indicated, horizontal and vertical piping attachments shall conform to MSS SP 58. Provide metal protection shields and inserts for insulated piping in accordance with Section 23 07 00, "HVAC Insulation".

1. Maximum Spacing Between Supports:
   a. Vertical Piping: Support metal piping at not more than 10-foot intervals.
   b. Horizontal Piping: Support piping and copper tubing as follows, unless indicated otherwise:

MAXIMUM SPACING (FEET)						
Nominal Pipe Size (Inches)	One and Under	1.25	1.5	2	2.5	3 and Over
Copper Tube	6	6	7	7	8	8

I. Pipe Sleeves: Provide sleeves where pipes and tubing pass through masonry or concrete walls, floors, roof, and partitions. Sleeves in outside walls below and above grade, in floor, or in roof slabs, shall be steel pipe. Sleeves in partitions shall be zinc coated sheet steel having a nominal weight of not less than 0.906 pound per square foot. Space between pipe, tubing, or insulation and the sleeve shall be not less than 1/4 inch. Hold sleeves securely in proper position and location before and during construction. All sleeves shall be of sufficient length to pass through entire thickness of walls, partitions, or slabs. Sleeves in floor slabs shall extend 2 inches above the finished floor. Firmly pack space between the pipe or tubing and the sleeve with oakum and calk on both ends of the sleeve with elastic cement.

3.03 REFRIGERANT PIPING:

A. Fabrication and Assembly of Piping and Components: Fabrication, heating, soldering, brazing, and welding of piping and components shall conform to ANSI B31.5 and ANSI 15 and as specified herein. Clean, seal, plug, or cap piping prior to delivery to the site. Refrigerant piping shall be brazed with 15 percent silver solder in accordance with AWS A5.8, minimum melting point 1500 degrees F for pressures up to 120 psi. Refrigerant connections to components shall have stop valves to permit servicing of the components without pumping out other than the components themselves. Refrigerant piping shall slope in the direction of refrigerant flow.

B. Refrigerant Driers: Install in the main liquid line leaving the high pressure receiver or condenser receiver, with isolating service valves and valved bypass

lines which are the same size as the liquid line in which the drier is installed. Install driers with the cover accessible for removing the cartridge.

C. Sight Glass Liquid Indicator: Install in the main high pressure liquid line. Indicator connection shall be the same size as the liquid line in which installed.

3.04 CLEANING, PAINTING AND IDENTIFICATION

A. When installations of the various components of the piping systems are completed, clean before final closing. Clean all piping and components of scale and thoroughly flush out all foreign matter. Clean all strainers and valves thoroughly. Wipe equipment clean, removing all traces of oil, dust, dirt, or paint spots. Maintain the system in this clean condition until final approval. Clean and paint piping and equipment, as required.

B. Safety Procedure: Ventilate work area, avoiding skin contact by using solvent resistant gloves. Observe precautions and warnings on the manufacturer's product labels.

C. Exposed piping shall be painted for the purpose of color coding in accordance with Section 23 05 53, “Identification For HVAC Piping & Equipment”. Provide painting in accordance with Section 09 91 23, "Interior Painting".

3.05 TESTING

A. After completion of the piping installation and prior to initial operation, conduct tests on the piping system. Furnish materials and equipment required for tests. Correct defects disclosed by the test. Perform test after installation and prior to acceptance in the presence of the Owner's Representative and subject to his approval.

1. Refrigerant Piping System: Test the piping system and condensing units for tightness after installation and before insulation is applied. Temporarily remove controls and other equipment that may be damaged by the test pressure or make inoperative before the tests are made, and plug or cap openings. Correct threaded, soldered, or brazed joints that leak by remaking the joints. Repair welded joints that leak by cutting out the faulty weld affected section and rewelding the joint or renewing the section of pipe.
    a. Test Pressures: Refrigerant system test pressures for tightness shall not be less than ANSI 15 or ANSI B31.5 test pressures specified.
    b. Charging the System for Test: Charge the low and high pressure side of the system with a dry, inert gas, such as nitrogen or anhydrous carbon dioxide using a small amount of the refrigerant gas to act as a tracer. Use a pressure limiting or reducing valve with pressure gauge on the high pressure gas tank to limit the pressure in the system to the specified test pressure for the respective refrigerant.
    c. Leakage Test: With the system charged to the desired pressure, tightly shut off the gas supply and hold the system for 30 minutes, during which time there shall be no loss of pressure. If a pressure

drop, not attributable to temperature changes, occurs during this period, check the entire system with a halide torch or an electronic leak detector. When leaks are found, make repairs and provide another 30 minute period at the test pressure. Testing and repair shall continue until there is no loss of pressure.

d. Evacuation: After completion of testing of refrigerant system for leaks, remove all air and moisture from the system by using a high vacuum pump. When a satisfactory vacuum has been obtained, break the vacuum by introducing vapor (no liquid) and subsequently seal off the system. Provide a nitrogen holding charge for piping and equipment. Final refrigerant charging will be performed by Carrier.

3.06 STARTUP AND OPERATIONAL TESTS:

A. Start up and initially operate the system. During this time, periodically clean the various strainers until no further accumulation of foreign material occurs. Exercise care so that minimum loss of refrigerant occurs when strainers are cleaned. Adjust safety and automatic control instruments as necessary to place them in required operation and sequence.

END OF SECTION

SECTION 23 31 13
DUCTWORK AND DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY

A. Under this Section, the Contractor shall furnish all labor, materials and equipment for Ductwork and Ductwork Accessories, as shown on the Plans, as specified and/or directed.

B. Related work specified elsewhere:
1. Division 1 – General Requirements
2. Section 23 05 00 – General Mechanical Requirements
3. Section 23 05 53 – Identification for HVAC Piping and Equipment
4. Section 23 05 93 – Testing and Balancing Air and Water Systems
5. Section 23 07 00 – HVAC Insulation
6. Section 23 37 13 – Diffusers, Registers and Grilles

1.02 REFERENCE STANDARDS

A. The following is a list of standards that may be referenced in this Section:
1. Air Diffusion Control (ADC) Publication:
   a. 1062-R4 – Certification, Rating and Test Manual
   b. AD – Measurement of Room to Room Sound Transmissions Through Plenum Air Systems
2. Air Movement and Control Association, Inc. (AMCA) Publication:
   a. 500 – Test Methods for Louvers, Dampers and Shutters
3. American Society for Testing and Materials (ASTM) Publication:
   a. A123 – Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
   b. A167 – Stainless and Heat Resisting Chromium Nickel Steel Plate, Sheet, and Strip
   c. A653 – Steel Sheet, Zinc-Iron Alloy coated (Galvanized) by the Hot Dip Process
   d. B117 – Salt Spray (Fog) Testing
   e. B127 – Nickel Copper Alloy (UNS N04400) Plate, Sheet, and Strip
   f. B209 – Aluminum and Aluminum-Alloy Sheet and Plate
   g. C423 – Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
   h. C553 – Mineral Fiber Blanket and Felt Insulation (Industrial Type)
   i. D822 – Operating Light and Water Exposure Apparatus (Carbon Arc Type) for Testing Paint, Varnish, Lacquer, and Related Products
   j. D1654 – Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
   k. E84 – Test Method for Surface Burning Characteristics of Building Materials
   l. E90 – Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions

m. E96 – Water Vapor Transmission of Materials

4. National Fire Protection Association (NFPA) Publication:
   a. 90A – Installation of Air Conditioning and Ventilating Systems
5. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA) Publication:
   a. HVACTAB – HVAC Systems Testing, Adjusting and Balancing (HVACTAB)
   b. HVACDCS – HVAC Duct Construction Standards Metal and Flexible (HVACDCS)
   c. HVACALTM – HVAC Air Duct Leakage Test Manual (HVACALTM)
6. Underwriters Laboratories, Inc. (UL) Publications:
   a. 181 – Factory Made Air Duct Connectors
   b. 555 – Fire Dampers and Ceiling Dampers
   c. 555S – Leakage Rated Dampers for Use in Smoke Control Systems
   d. 586 – High Efficiency, Particulate, Air Filter Units
   e. 723 – Test for Surface Burning Characteristics of Building Materials
7. Uniform Fire Prevention and Building Code of New York State Publication:
   a. 2020 Mechanical Code
   b. 2020 Energy Conservation Construction Code

1.03 SUBMITTALS

A. Manufacturer’s Catalog Data:
   1. Dampers
   2. Flexible ducts and connectors
   3. Louvers
   4. Sheet Metals
   5. Test Holes

B. Drawings:
   1. Ductwork Layout Plan
   2. Location of test holes

C. Test Reports:
   1. Automatic dampers
      a. Submit certification of damper leakage testing and conformance with AMCA 500, the International Energy Conservation Code and Supplement, and specified maximum leakage or pressure drop requirements.
   2. Corrosion protection

D. Certificate of Compliance:
   1. Fire dampers and automatic dampers

E. Field Test Reports:
   1. Testing and balancing of air systems

1.04 QUALITY ASSURANCE

A. SMACNA Duct Construction Manuals: The SMACNA recommendations shall be considered as mandatory requirements. Substitute the word "shall" for the word "should" in these manuals. No negative pressure construction for 4 inch, 6 inch, or 10 inch water gauge is provided herein.

1.05 TESTING FOR CORROSION PROTECTION

A. Comply with ASTM A123 or protect the equipment with a corrosion inhibiting coating or paint system that has proved capable of satisfactorily withstanding corrosion in accordance with ASTM B117. Test 125 hours for equipment installed indoors and 500 hours for equipment installed outdoors or subjected to marine atmosphere. Each specimen shall have a standard scratch as defined in ASTM D1654.
   1. Corrosion Criteria: Upon completion of exposure, coating or paint shall show no indication of deterioration or loss of adhesion, nor shall there be indication of rust or corrosion extending further than 1/8 inch on either side of original scratch.
   2. Thickness of Coating: Thickness of coating or paint system on the actual equipment shall be identical to that on the test specimens with respect to materials, conditions of application, and dry film thickness.

1.06 PRESSURE VELOCITY CLASSIFICATION

A. SMACNA HVACDCS, Section 1, and as indicated.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Galvanized Steel Sheets: ASTM A653; coating designation G90.

B. Galvanized Steel Hot Dipped After Fabrication: ASTM A123.

C. Aluminum Alloy Sheets: ASTM B209

D. Corrosion Resisting (Stainless) Steel Sheets: ASTM A167.

E. Duct Liner Adhesives: SMACNA HVACDCS, fire resistant adhesive.

2.02 DUCTS OF PRESSURE CLASSES 2-INCH OR LESS WATER GAUGE

A. Construction, metal gauge, hangars and supports, and reinforcements shall conform with SMACNA HVACDCS. Ductwork shall be airtight and shall not vibrate or pulsate when system is in operation. Air leakage shall be less than 5 percent of the system capacity. Construct ductwork of galvanized steel.
   1. Curved Elbows: Make a center line radius not less than 1-1/2 times the width or diameter of the duct.

2. Joints: Make airtight. No dust marks from air leaks shall show at duct joints or connections to grilles, registers, and diffusers.
3. Laps: Make laps at joints in the direction of airflow. Space button punch or bolt connection in standing seams at fixed centers not greater than 6 inches. Longitudinal locks or seams, known as "Button Punch Snap Lock" may be used in lieu of Pittsburg Lock.
4. Fittings: Elbows, vaned elbows, take offs, branch connections, transitions, splitters, volume dampers, fire dampers, flexible connections, and access door shall conform with SMACNA HVACDCS, Section 2. Factory fabricate test holes to be airtight and noncorrosive with screw cap and gasket.

2.03 FLEXIBLE DUCTS

A. UL 181, Class I, UL listed, SMACNA HVACDCS, and additional requirements herein specified. Use to connect between rigid ducts and outlets or terminals. There shall be no erosion, delamination, loose fibers, or odors from the ducts into the air stream. At 250 degrees F, minimum rating pressures shall be 2 inches water positive and 1-1/2 inches negative up to 2500 cfm flexible ducts. Flexible ducts shall be maximum 3 feet in length. Minimum bend radius shall be twice of the duct diameter.
1. Materials: Interlocking spiral or helically corrugated type constructed of noncollapsible fire retardant, chloroprene or chlorosulphonated polyethylene impregnated, minimum 30 ounces per square yard woven mineral fabric.
2. Insulation and Vapor Barrier: ASTM C553; minimum one inch nominal thickness and one lb./cu. ft. density. The insulation shall be sheathed with a vapor barrier having a maximum water vapor permeance of 0.02 perm per ASTM E96, Procedure C. Coat ends of insulation with cement to prevent erosion and delamination.
3. Joints: Make airtight slip joints, seal with pressure sensitive vapor seal adhesive tape or duct sealer, and secure with sheet metal screws. To prevent insulation compression, place 2 inch wide by one inch thick closed cell foam plastic spacers over the joints under vapor barriers. To provide a vapor-tight joint, use a zinc coated steel clamp over such spacers.

2.04 FLEXIBLE CONNECTORS

A. UL 181, Class I, UL listed, SMACNA HVACDCS, and additional requirements herein specified. Connectors to be ASTM A653, 24-gauge galvanized steel, with commercial neoprene fire retardant coating meeting NFPA 701 with 500 lb tensile strength at a temperature range of -40ºF to 200ºF. Use to connect between rigid ducts and equipment inlets and outlets as indicated. There shall be no erosion, delamination, loose fibers, or odors from the ducts into the air stream.

2.05 DUCT SLEEVES AND PREPARED OPENINGS

A. Duct Sleeves and Closure Collars: Fabricate from minimum 20 gauge galvanized steel. Where sleeves are installed in bearing walls, provide structural steel sleeves as indicated.

B. Prepared Openings: Provide one inch clearance between the duct and the sleeve.

2.06 DEFLECTORS

A. Factory fabricated and factory or field assembled units consisting of curved turning vanes for uniform air distribution and change of direction with minimum turbulence and pressure loss. Provide curved vanes for square elbows.

B. For round ducts taking off from rectangular ducts, provide factory fabricated, galvanized sheet metal, spin in fittings. These fittings shall have scoop extractors, butterfly dampers, and locking quadrant operators.

2.07 ACCESS DOORS

A. Weld door frame in place. Door shall be rigid and airtight with neoprene gaskets and two or more galvanized steel hinges and tension fasteners. Provide doors as large as practical. Mount doors, if possible, so that air pressure holds them closed.

2.08 DAMPERS AND LOUVERS

A. Construct dampers and louvers with two gauges heavier than ducts in which installed. Except as modified herein, the construction shall be of aluminum or galvanized steel with interlocking edges and maximum 10 inch blade width. Conform with SMACNA HVACDCS. Dampers shall be opposed blade type where indicated.

B. Backdraft Dampers (Gravity Dampers or Shutters): Factory fabricated, with statically and dynamically balanced blades that open automatically when the fan starts and close by gravity when the fan stops. Provide the edges of blades with felt or rubber strips to prevent rattling.

C. Manual Volume Dampers: Balancing, factory fabricated type. Equip dampers with accessible mechanism such as quadrant operators or 3/16 inch rods brought through the side of ducts with locking setscrew and bushing. Where quadrant operators are used, they shall be chrome plated or enamel painted with all exposed edges rounded.

D. Fire Dampers: Provide in accordance with UL 555. Units shall be accordion type with 180° F fusible link with rating to match chase enclosure. Pressure drop in open position shall not exceed 0.1 inch w.g. Damper shall be designed for and labeled for use in dynamic systems. Static only damper labels are not permissible. The damper shall be rated for dynamic closure at air velocities and

static pressures that will be encountered in the application. The damper shall be tested and rated to close with airflow in either direction.

E. Automatic Dampers: Opposed blade dampers, factory fabricated of extruded aluminum, zinc-coated steel or stainless steel, with antifriction nonferrous bearings. Damper construction shall be in accordance with SMACNA Low Pressure Duct Construction Standards. Damper blades are to be foam insulated and thermally broken along with damper frame, leakage not to exceed 4" CFM/sq. ft. against 4" w.g. Damper operators shall have sufficient power to limit air leakage to the specified rate. Spring set to return to closed position and matching 120V actuator is to be provided as manufacturer accessory.

F. Louvers: Fixed type, performance based on testing in accordance with AMCA Standard 500. Fold or bead the edges of louver blades to exclude driving rain. Make louver frames of extruded aluminum and shall include extended sills. Provide bird (insect) screen constructed of the same type metal as the louvers in a removable, rewireable frame. All louver components to be factory assembled. All performance and size characteristics shall be as scheduled.

G. Bird Screens: ASTM E437, general industrial-use wire cloth, Grade C, (medium light) or heavier, nominal 2 mesh 0.063-inch wire diameter, aluminum bird screens. Provide removable insect screens of grooved type, with vinyl or neoprene spline insert for securing screen cloth.

2.09 DUCTWORK AND EQUIPMENT INSULATION

A. Section 23 07 00, "HVAC Insulation".

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation shall conform to NFPA 90A, SMACNA HVACDCS. Provide mounting and supporting of ductwork and accessories including, but not limited to, structural supports, hangers, vibration isolators, stands, clamps and brackets, access doors, and dampers. Use electrical isolation between dissimilar metals. Electrical isolation may be fluorinated elastomers or sponge rubber gaskets. Install ductwork accessories as indicated in accordance with the manufacturer's printed instruction. Allow clearance for inspection, repair, replacement, and service.

1. Ductwork: When air distribution systems are operated, there shall be no chatter, vibration, or dust marks. After ducts are thermally or acoustically insulated, ensure air flow area equal to duct cross section dimensions indicated.
    a. Field Changes to Ductwork: Those required to suit the sizes of factory fabricated equipment actually furnished, shall be designed to minimize expansion and contraction. Use gradual transitions in field changes as well as modifications to connecting ducts.
    b. Dampers: When installed on ducts to be thermally insulated, equip each damper operator with stand-off mounting brackets,

bases, or adapters to provide clearance between the duct and operator not less than the thickness of insulation. Stand-off mounting items shall be integral with the operator or standard accessory of damper manufacturer.

c. Deflectors: Provide in square elbows, duct mounted supply outlets, take off or extension collars to supply outlets, and tap in branch off connections. Adjust supply outlets to provide air volume and distribution as indicated or specified.

d. Fire Dampers: Install for ducts penetrating fire walls and where duct systems serve two or more floors in accordance with UL 555.

e. Access Doors: Provide for automatic dampers, volume dampers, fire dampers, coils, thermostats, temperature controllers, valves, filters, humidifiers and other concealed apparatus requiring service and inspection in the duct systems.

f. Duct Sleeves and Prepared Openings: Install for duct mains, duct branches, and ducts passing through roofs and ceilings. The Contractor shall be responsible for the proper size and location of sleeves and prepared openings.

1) Duct Sleeves: Allow one inch clearance between duct and sleeve or one inch clearance between insulation and sleeve for insulated ducts, except at grilles, registers, and diffusers.

2) Prepared Openings: Allow one inch clearance between duct and opening or one inch clearance between insulation and opening for insulated ducts, except at grilles, registers, and diffusers.

3) Closure Collars: Provide not less than 4 inches wide on each side of walls or floors where sleeves or prepared openings are installed. Fit collars snugly around ducts and insulation. Grind smooth edges of collar to preclude tearing or puncturing insulation covering or vapor barrier. Use nails with maximum 6 inch centers on collars.

2. Duct Hangers and Supports: SMACNA HVACDCS, Section 4. Unless otherwise indicated, provide not less than two one inch by 1/16 inch galvanized strap iron hangers spaced one on each side of duct. Anchor risers in the center of the vertical run to allow ends of riser free vertical movements. Attach supports only to structural framing members and concrete slabs. Do not anchor supports to metal decking unless a means is provided and approved for preventing the anchors from puncturing the metal decking. Where supports are required between structural framing member, provide suitable intermediate metal framing. Where C clamps are used, use retainer clips.

a. Flexible Ducts: Support ducts by hangers every 3 feet. Use stretch flexible air ducts to smooth out corrugations, and long radius elbows, where possible, using a minimum length to make connections.

b. Flexible Connectors: Provide flexible connectors between fans and ducts or casings and where ducts are of dissimilar metals. For round ducts, securely fasten flexible connectors by zinc

coated steel clinch type draw bands. For rectangular ducts, lock flexible connectors to metal collars.

3. Flashings: Provide waterproof flashings where ducts pass through exterior walls and roofs.
4. Inspection Plates and Test Holes: Provide, where required, in ductwork or casings for all balance measurements. Test holes shall be factory fabricated, airtight, and noncorrosive with screw cap and gasket. Extend cap through insulation.
5. Cleaning of Ducts: Remove all debris and dirt from ducts and wipe clean. Before installing air outlets, use air handler to blow dry air through entire system at maximum attainable velocity. Provide temporary air filters for this operation.

3.02 TESTING AND COMMISSIONING

A. The Contractor is responsible for the administration and direction of tests. Furnish instruments, equipment, connecting devices, and personnel for the tests. Notify Engineer 5 days before inspection or testing is scheduled. Correct all defects in the work. Repeat tests until the work is in compliance.
   1. Performance Testing and Balancing: Section 23 05 93, “Testing and Balancing Air and Water Systems”.

END OF SECTION

SECTION 23 34 01
HVAC FANS

PART 1 - GENERAL

1.01 SUMMARY

A. Under this Section, the Contractor shall furnish all labor, materials and equipment for HVAC Fans, as shown on the Plans, as specified and/or directed.

B. Related Work specified elsewhere:
1. Section 23 05 00 – Mechanical General Requirements
2. Section 23 05 93 – Testing and Balancing Air and Water Systems
3. Section 23 31 13 – Ductwork and Ductwork Accessories
4. Section 23 37 13 – Diffusers, Registers and Grilles
5. Division 26 – Electrical

1.02 REFERENCE STANDARDS

A. The following is a list of standards that may be referenced in this section:
1. Air Movement and Control Association, Inc. (AMCA) Publications:
   a. 210 – Laboratory Method of Testing Fans for Rating
   b. 220 – Test Method for Air Curtains
   c. 300 – Reverberant Room Method for Sound Testing of Fans
2. Air-Conditioning, Heating and Refrigeration Institute (AHRI) Publications:
   a. 880 – Air Terminals
3. Acoustical Society of America (ASA) Publication:
   a. 13 – Determination of Sound Levels of Noise Sources in a Special Reverberation Test Room
4. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE) Publication:
   a. 68 – Testing In-Duct Sound Power Measurement Procedure for Fans
5. American Society for Testing and Materials (ASTM) Publications:
   a. A123 – Zinc (Hot Dip Galvanized) Coatings on Iron Steel Products
   b. B117 – Salt Spray (Fog) Testing
   c. D1654 – Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
6. National Electrical Manufacturers Association (NEMA) Publications:
   a. ICS2 – Industrial Control Devices, Controllers and Assemblies
   b. ICS6 – Enclosures for Industrial Controls and Systems
   c. MG1 – Motors and Generators
7. National Fire Protection Association (NFPA) Publications:
   a. 70 – National Electrical Code
   b. 90A – Installation of Air Conditioning and Ventilating Systems
8. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA) Publications:
   a. HVACTAB – HVAC Systems Testing, Adjusting and Balancing (HVACTAB)

9. Underwriters Laboratories, Inc. (UL) Publications:
   a. 507 – Electric Fans
   b. 705 – Power Ventilators
   c. 1278 – Wall- or Ceiling-Hung Electric Room Heaters
   d. 1995 – Terminal Units
10. Uniform Fire Prevention and Building Code of New York State Publications:
   a. 2020 Mechanical Code
   b. 2020 Energy Conservation Construction Code

1.03 SUBMITTALS

A. Manufacturer's Data: Shop Drawings and Catalog Cuts. Submit shop drawings and catalog information showing plan, elevations, dimensions, capacities, accessories, controls, wiring diagrams, and ratings for the following:
   1. Fans
   2. Gravity Ventilator
   3. Roof Curbs
   4. Electric Unit Heaters

B. Certificates of Compliance:
   1. Fans
   2. Gravity Ventilator

C. Operation and Maintenance Manuals:
   1. Fans
   2. Gravity Ventilator
   3. Electric Unit Heaters

1.04 MOTORS

A. NEMA MG1. Motor starters shall conform to NEMA ICS1 and NEMA ICS2. Determine specific motor characteristics to insure provision of correctly sized starters and overload heaters. Motors shall be designed to operate at full capacity with a voltage variation of plus or minus 10 percent of the motor voltage rating. Motor size shall be sufficient for the duty to be performed and shall not exceed its full load nameplate current rating when driven equipment is operated at specified capacity under the most severe conditions likely to be encountered. When motor size provided differs from the size indicated or specified, the Contractor shall make the necessary adjustments to the wiring, disconnect devices, and branch circuit protection to accommodate the equipment actually provided.

1.05 TESTING FOR CORROSION PROTECTION

A. Comply with ASTM A123, or protect the equipment with a corrosion inhibiting coating or paint system that has proved capable of satisfactorily withstanding corrosion in accordance with ASTM B117. Test 125 hours for equipment installed indoors and 500 hours for equipment installed outdoors or subjected to a marine atmosphere. Each specimen shall have a standard scratch as defined in ASTM D1654.

B. Corrosion Criteria: Upon completion of exposure, coating or paint shall show no indication of deterioration, loss of adhesion, or any indication of rust or corrosion extending further than 1/8 inch on either side of original scratch.

C. Thickness of Coating: Thickness of coating or paint system on the actual equipment shall be identical to that on the test specimens with respect to materials, conditions of application, and dry film thickness.
   1. Mild Steel and Factory Primed Surfaces:
      a. Synthetic Resin Primer: 36 percent plus or minus 6 percent solids content by volume; 1 coat, 3 mils minimum dry film thickness.
      b. Vinyl Copolymer: 23 percent plus or minus 4 percent solids content by volume; 2 coats, 1-1/2 mils minimum dry film thickness per coat.
   2. Nonferrous Heat Exchanger Fin Coil Surfaces: Vinyl copolymer, 4 coats, 1-1/2 mils minimum dry film thickness per coat.
   3. Galvanized Surfaces:
      a. Polyamide Epoxy Primer: 48 percent plus or minus 2 percent solids content by volume; 1 coat, 2 mils minimum dry film thickness.
      b. Vinyl Copolymer: 23 percent plus or minus 4 percent solids content by volume; 2 coats, 1-1/2 mils minimum dry film thickness per coat.
   4. Aluminum Surfaces Other than Fin Coil Surfaces:
      a. Polyamide Epoxy Primer: 48 percent plus or minus 2 percent solid contact by volume; 1 coat, 2 mils minimum dry film thickness.
      b. Vinyl Copolymer: 23 percent plus or minus 4 percent solids content by volume; 2 coats, 1-1/2 mils minimum dry film thickness per coat.

PART 2 - PRODUCTS

2.01 FANS

A. Sound rating per AMCA 300; statically and dynamically balanced, with air capacities, brake horsepowers, fan types, fan arrangement, sound power levels or loudness level, and static pressure, as indicated. Fan bearing life shall have a minimum average life of 200,000 hours at design operating conditions. Provide guard (bird) screens for outdoor inlets and outlets. Equip with automatic (back-draft) dampers. Have thermal overload protection in the operating disconnect switches within the building.

B. Centrifugal Fans: AMCA 210 with AMCA seal, galvanized steel housing, forward-curved type, direct drive motors, and injected molded polypropylene fan wheel and housing. Inlet box shall be 22-gauge galvanized steel with isolation mounted motor and galvanized steel motor mount. Motor shall be permanently lubricated, with built-in impedance or thermal overload protection, and disconnect plug. Provide with backdraft damper, isolator kit, 120V pre-wired fan speed controller, white aluminum grille, interlock operation with light switch and insulated housing. Provide with brick vent exhaust opening, 4-inch deep frame

and 45 degree blades in locations indicated on contract drawings. Manufacture shall be as by Loren Cook Gemini Series, or approved equal.

C. Rooftop Exhaust Fans: AMCA 210 with AMCA seal, UL listed, downblast type with aluminum wheel, backward inclined centrifugal, statically and dynamically balanced, rigid internal support structure, leak proof, 16-gauge aluminum motor cover, shroud, curb cap and lower windband. Shroud shall have integral rolled bead, and lower windband shall have a formed edge. Drive frame assemblies shall be constructed of 14-gauge steel and mounted on rubber vibration isolators. Fan shall have aluminum bird screen, aluminum hinges, 120V fan speed controller, and backdraft damper. Fan shall be provided with baked polyester powder coating electrostatically applied (color by Owner). Manufacture shall be as by Loren Cook ACE-D Series, or approved equal.

D. Gravity Ventilators: Spun aluminum, bolted and welded construction utilizing corrosion resistant fasteners. Spun aluminum structural components shall be 16-gauge marine alloy aluminum, bolted to a rigid aluminum support structure. Aluminum base shall have continuously welded curb cap corners. Manufacture shall be as by Loren Cook Model PR, or approved equal.

E. Roof Curbs: Factory-fabricated sheet-steel structural members complying with National Roofing Contractors Association (NRCA) requirements. The curbs shall have high load-bearing capacities attained by a system of internal bulkheads, welded into position at logical intervals along the length of rails. Provide minimum 4-inch cants, 2- by 6-inch factory-installed wood nailers, and fully mitered end sections. Use welded 18-gauge galvanized steel shell, baseplate, and counterflashing.

2.02 ELECTRIC UNIT HEATERS

A. UL 1278, heavy-duty, wall-mounted forced-air electric unit heaters of the wattage, voltage and phase as indicated. Casing shall be 18-gauge steel with combination louvered supply and return grill assembly on the front. Motor shall be permanently lubricated, total enclosed, shaded pole type with impedance protection and thermal overload. Element assemblies consist of two corrosion-resistant steel sheathed type elements mechanically bonded to common corrosion resistant steel fins. Each element shall be of helically coiled nickel chromium alloy resistant wire completely embedded in and surrounded by magnesium oxide, enclosed and wedged into corrosion resistant steel sheaths. Unit shall be controlled by an integrally mounted, thermostat with remote sensing bulb in the return air. Manufacture shall be as by Reznor Model EHC, or approved equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install air distribution equipment as indicated and in accordance with the manufacturer's instructions. Provide clearance for inspection, repair, replacement, and service. Electrical work shall conform with NFPA 70 and

Division 26, "Electrical". Provide overload protection in the operating disconnect switches and magnetic starters.

3.02 FIELD INSPECTION AND TESTS

A. Schedule and administer the specified tests. Provide personnel, instruments, and equipment for such tests. Correct defects and repeat the respective inspection and tests. Give the Engineer ample notice of the dates and times scheduled for tests and trial operations. Conduct inspection and testing in the presence of the Engineer.
   1. Field Inspection: Prior to initial operation, inspect equipment installation for conformance with drawings and specifications.

B. Field Tests:
   1. Preliminary Tests: For each item of air handling and distribution equipment and its components, perform an operational test for a minimum period of 4 hours.
   2. Testing and Balancing: After preliminary tests, test, adjust, and balance the air handling and distribution equipment in accordance with Section 23 05 93, "Testing and Balancing Air and Water Systems".

3.03 INSTRUCTION OF OPERATING PERSONNEL

A. Upon completion of the work, and acceptance of the installation, and at a time designated by the Owner, the services of a competent technician regularly employed or authorized by the manufacturer of the compactor shall be provided for instructing personnel in the proper operation, maintenance, safety and emergency procedures. The period of instruction shall be not less than two hours. The training shall be conducted at the job site during actual operation and coordinated with the Owner one week in advance.

END OF SECTION

SECTION 23 37 13
DIFFUSERS, REGISTERS AND GRILLES

PART 1 - GENERAL

1.01 SUMMARY

A. Under this Section, the Contractor shall furnish all labor, materials and equipment for Diffusers, Registers and Grilles, as shown on the Plans, as specified and/or directed.

B. Related Work specified elsewhere:
   1. Section 23 05 00 – Mechanical General Requirements
   2. Section 23 05 93 – Testing and Balancing of Air and Water Systems
   3. Section 23 31 13 – Ductwork and Ductwork Accessories

1.02 REFERENCE STANDARDS

A. The following is a list of standards that may be referenced in this section:
   1. Air Diffusion Control (ADC) Publication:
      a. 1062-R4 – Certification, Rating and Test Manual
      b. AD – Measurement of Room to Room Sound Transmissions Through Plenum Air Systems
   2. Air Conditioning, Heating and Refrigeration Institute (AHRI) Publication:
      a. 881 – Performance Rating of Air Terminals
   3. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE) Publication:
      a. 70 – Performance of Air Outlets and Air Inlets Testing Method
   4. American Society for Testing and Materials (ASTM) Publication:
      a. A123 – Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
      b. A527 – Steel Sheet, Zinc Coated (Galvanized) by the Hot Dip Process Lock Forming Quality
      c. B117 – Corrosive Environments Salt Spray Test
      d. C423 – Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
      e. C553 – Mineral Fiber Blanket and Felt Insulation for Commercial and Industrial Applications
      f. D870 – Water Immersion Test
      g. D2794 – Reverse Impact Cracking Test
   5. National Fire Protection Association (NFPA) Publication:
      a. 90A – Installation of Air Conditioning and Ventilating Systems
   6. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA) Publications:
      a. HVACTAB – HVAC Systems Testing, Adjusting and Balancing (HVACTAB)
      b. HVACDCS – HVAC Duct Construction Standards Metal and Flexible (HVACDCS)

7. Underwriters Laboratories, Inc. (UL) Publication:
   a. 181 – Factory Made Air Duct Connectors
8. Uniform Fire Prevention and Building Code of New York State Publication:
   a. 2020 Mechanical Code

1.03 SUBMITTALS

A. Manufacturer's Data:
   1. Diffusers, registers and grilles
      a. Submit a schedule of all inlets and outlets indicating location, catalog model number, manufacturer, dimensional information, sound pressure level rating, nominal rated volumetric flow rate (cfm), neck or face velocity at specified cfm, pressure drop at specified cfm, throw and drop for outlets, range for diffusers, and maximum and minimum cfm modulation.

B. Test Reports:
   1. Sound pressure level rating
      a. Submit for inlets and outlets including diffusers, registers and grilles.

1.04 QUALITY ASSURANCE

A. SMACNA Duct Construction Manuals: The SMACNA recommendations shall be considered as mandatory requirements. Substitute the word "shall" for the word "should" in these manuals.

PART 2 - PRODUCTS

2.01 DIFFUSERS, REGISTERS, AND GRILLES

A. Material and Finishes: Construct diffusers, registers, and grilles of steel or aluminum as indicated. Exterior and exposed edges shall be rolled, or otherwise stiffened and rounded. Air outlets shall be factory treated and painted with a baked on anodic acrylic paint and pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering or deterioration of film. The paint must also meet testing requirements in accordance with ASTM B870 and D2794. Colors shall be selected or approved by the Engineer.

B. Sound Pressure Level: Manufacturer certified sound pressure level rating of inlets and outlets in accordance with ADC 1062 R4. Conform with the following permissible room sound pressure levels:

NC Range, dB	Typical Application
10 – 15	Room 205
20 – 25	Private Offices and Conference Rooms
30 – 40	Corridors
25 – 30	Classrooms
20 – 25	Courtrooms

C. Throw: Defined as distance from the diffuser, register, or grille to the point which the air velocity falls below 50 feet per minute. Throw shall not exceed 1.5 times the outlet mounting height.

D. Drop: Maximum drop of air stream shall not be so great that it is within 5 feet of the floor at the end of the throw.

E. Ceiling Diffusers: Equip with baffles or other devices required to provide proper air distribution pattern. Provide factory fabricated, single key, volume dampers. Except for linear air diffusers, internal parts shall be removable through the diffuser neck for access to the duct and without the use of special tools.
   1. Circular, Square, and Rectangular Diffusers: Construct each ceiling diffuser of three precision die-stamped cones designed to deliver air in a generally horizontal direction without excess smudging of the ceiling. The back cone shall include an integrally drawn inlet. The two inner cones shall be constructed as a single, removable inner core assembly with removal center plug to allow adjustment of inlet damper without removal of inner core assembly. Diffusers shall be supplied with a round damper operable from the face of the diffusers. Diffusers shall be steel, and a lay-in type or plaster mounted frame of 24”x24” or 12”x12” as indicated. Manufacture shall be as by Titus Model TMS, or approved equal.
   2. Linear Louver Diffusers: Constructed of extruded aluminum, built in standard one-piece lengths to 6 feet, with fixed extruded aluminum deflection louvers, opposed blade damper of heavy gauge steel operable from the face, and one-way horizontal discharge pattern. Manufacture shall be as by Titus Model LL-1, or approved equal.

F. Supply Registers: Double deflection steel supply registers with front deflection blades parallel to the long dimension of the register. Blades shall be spaced on 3/4-inch centers. Provide manufacturer furnished volume dampers furnished by the manufacturer. Volume dampers shall be of the group operated, opposed blade type and key adjustable by inserting key through face of register. Operating mechanism shall not project through any part of the register face. Manufacture shall be as by Titus Model 300 RL, or approved equal.

G. Return/Exhaust Registers: Provide exhaust and return registers as specified for supply registers, except that they shall have a single set of nondirectional face bars or vanes having the same appearance as the supply registers. Set face bars or vanes at 35 degrees. Registers shall be in lay-in type or plaster mounted frame as indicated. Manufacture shall be as by Titus Model 350 RL, or approved equal

PART 3 - EXECUTION

3.01 INSTALLATION

A. Installation shall conform to NFPA 90A, SMACNA HVACDCS. Install diffusers, registers, grilles and accessories as indicated in accordance with the manufacturer's printed instruction. Allow clearance for inspection, repair, replacement, and service.

3.02 FIELD TESTS AND INSPECTIONS

A. The Contractor is responsible for the administration and direction of tests. Furnish instruments, equipment, connecting devices, and personnel for the tests. Correct all defects in the work. Repeat tests until the work is in compliance.

1. Performance Testing and Balancing: Testing and Balancing shall be performed in accordance with Section 23 05 93, “Testing and Balancing Air and Water Systems”.

END OF SECTION

SECTION 23 81 26
UNITARY AIR CONDITIONING SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Under this Section, the Contractor shall furnish all labor, materials and equipment for Unitary Air Conditioning Systems, as shown on the Plans, as specified, and/or directed.

B. Related Work specified elsewhere:
1. Section 23 05 00 – Mechanical General Requirements
2. Section 23 05 53 – Identification for HVAC Piping and Equipment
3. Section 23 05 93 – Testing and Balancing Air and Water Systems
4. Section 23 07 00 – HVAC Insulation
5. Section 23 21 13 – Hydronic Piping & Specialties
6. Section 23 23 13 – Refrigerant Piping & Specialties
7. Section 23 31 13 – Ductwork and Ductwork Accessories
8. Section 23 37 13 – Diffusers, Registers and Grilles
9. Division 26 - Electrical

1.02 REFERENCE STANDARDS

A. The following is a list of standards that may be referenced in this section:
1. Air Conditioning, Heating and Refrigeration Institute (AHRI) Publication:
   a. 210 – Unitary Air Conditioning Equipment
   b. 260 – Application, Installation and Servicing of Unitary Systems
   c. 350 – Sound Rating of Non-Ducted Indoor Air Conditioning Equipment
   d. 360 – Commercial and Industrial Unitary Air Conditioning Equipment
   e. 410 – Forced Circulation Air-Cooled & Air-Heating Coils
   f. 440 – Fan Coil Units
   g. DCAACP – Directory of Certified Applied Air Conditioning Products
   h. DCUAC – Directory of Certified Unitary Air Conditioners
2. American National Standards Institute (ANSI) Publication:
   a. Z21.47 – Gas-fired Central Furnaces
3. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE) Publication:
   a. 15 – Safety Code for Mechanical Refrigeration
   b. 52 – Method of Testing Air-Cleaning Devices Used in General Ventilation for Removing Particular Matter
   c. 90.1-2016 - Energy Standard for Buildings Except Low-rise Residential Buildings
   d. 193 – Method of Testing for Determining the Airtightness of HVAC Equipment
   e. SHPD – Handbook and Product Directory Systems

4. American Society of Mechanical Engineers (ASME) Publication:
   a. BPVSEC8 – Boiler and Pressure Vessels Code Section VIII – Pressure Vessels, Division 1
5. American Society for Testing and Materials (ASTM) Publication:
   a. A53 – Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded and Seamless
   b. A120 – Pipe, Steel, Black and Hot Dipped Zinc Coated (Galvanized) Welded and Seamless, for Ordinary Uses
   c. A386 – Zinc Coating (Hot Dip) on Assembled Steel Products
   d. B88 – Seamless Copper Water Tube
   e. B117 – Salt Spray (Fog) Testing
   f. B209 – Aluminum and Aluminum Alloy Sheet and Plate
   g. B210 – Aluminum Alloy Drawn Seamless Tubes
   h. C534 – Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
   i. D1654 – Painted or Coated Specimens Subjected to Corrosive Environments
   j. D1785 – PolyVinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120
   k. D2564 – Solvent Cements for PolyVinyl Chloride (PVC) Plastic Piping Systems
   l. E84 – Test for Surface Burning Characteristics of Building Materials
   m. G-21 – Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi
6. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Publication:
   a. SP 58 – Pipe Hangers and Supports - Materials and Design
   b. SP 69 – Pipe Hangers and Supports - Selection and Application
7. National Electrical Manufacturers Association (NEMA) Publication:
   a. MG1 – Motors and Generators
   b. ICS1 – Industrial Control and Systems
   c. ICS2 – Industrial Controls Devices, Controllers and Assemblies
   d. ICS6 – Enclosures For Industrial Controls and Systems
8. National Fire Protection Association (NFPA) Publication:
   a. 54 – National Fuel Gas Code
   b. 58 – Liquefied Petroleum Gas Code
   c. 211 – Chimneys, Fireplaces, and Vents
9. Underwriters Laboratories, Inc. (UL) Publication:
   a. 484 – Room Air Conditioners
   b. 723 – Test for Surface Burning Characteristics of Building Materials
   c. 873 – Temperature Indicating and Regulating Equipment
   d. 1738 – Venting Systems for Gas-Burning Appliances, Categories II, III, and IV
   e. 1995 – Heating and Cooling Equipment
10. Uniform Fire Prevention and Building Code of New York State Publication:
    a. 2020 Energy Conservation Construction Code
    b. 2020 Fuel Gas Code

c. 2020 Mechanical Code

1.03 SUBMITTALS

A. Manufacturer's Data:
1. Fan Coil Units
2. Ductless Split Air Conditioning Units

B. Operation and Maintenance Manuals:
1. Fan Coil Units
2. Ductless Split Air Conditioning Units

C. Posted Operating Instructions:
1. Fan Coil Units
2. Ductless Split Air Conditioning Units

1.04 SAFETY STANDARD

A. Design, manufacture, and installation of mechanical refrigeration equipment shall conform to ASHRAE 15.

1.05 CORROSION PREVENTION:

A. Special protection is not required for equipment that has a zinc coating conforming to ASTM A386 or a duplex coating of zinc and paint. Where expressly stipulated in equipment requirements paragraphs below, the affected equipment items shall be protected by the manufacturer with a corrosion inhibiting coating or paint system that has been proved capable of satisfactorily withstanding the following test. Test method shall be ASTM B117. Period of test shall be 125 hours for equipment intended for installation indoors; test period shall be 500 hours for equipment which will be installed outdoors or which will be otherwise subjected to marine atmosphere. Each specimen shall have a standard scratch as defined in ASTM D1654.
1. Corrosion Criteria: Upon completion of exposure, coating or paint shall show no indication of deterioration or loss of adhesion, nor shall there be indication of rust or corrosion extending further than 1/8 inch on either side of original scratch.
2. Thickness of Coating: Thickness of coating or paint system on the actual equipment shall be identical to that on the test specimens with respect to materials, conditions of application, and dry film thickness.

1.06 MOTORS:

A. Motor starters shall conform to NEMA ICS1 and NEMA ICS2. Determine specific motor characteristics to insure provision of correctly sized starters and overload heaters. Motors shall be designed to operate at full capacity with a voltage variation of plus or minus 10 percent of the motor voltage rating. Motor size shall be sufficient for the duty to be performed and shall not exceed its full load nameplate current rating when driven equipment is operated at specified capacity under the most severe conditions likely to be encountered. When motor size provided differs from the size indicated or specified, the Contractor shall make

the necessary adjustments to the wiring, disconnect devices, and branch circuit protection to accommodate the equipment actually provided.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Fan Coil Units: AHRI 440 certified, UL 1995 listed, factory fabricated, ceiling mounted horizontal style, with heavy gauge steel panels, suitable for duct connections indicated, and elastomeric closed cell foam insulation conforming to UL 181 for erosion and NFPA 90A for fire, smoke and melting. Insulation shall comply with a 25/50 flame spread and smoke developed index per ASTM E-84 or UL 723. Insulation shall also comply with antimicrobial performance rating of 0, no observed growth, per ASTM G-21. Unit shall be provided with a fully insulated mixing box section with return and outside dampers, including interconnecting damper linkage. Manufacture shall be as by John Controls Model FN, or approved equal.

1. Fans: Fans shall be forward curved, DWDI centrifugal type construction of 18-gauge zine coated galvanized steel. Fan assembly shall be easily removable. Fan motor shall be high efficiency, electronically commutated (EC) capable of variable speed operation and accepting a 2-10 VDC output from the existing Building Energy Management System.
2. Coils: AHRI 410 certified, with seamless copper tubes mechanically expanded for bond with tube and fin. Fins shall have a high efficiency aluminum surface. Coils shall be hydrostatically tested to 450 PSIG air pressure under water, and rated for a maximum of 450 PSIG working pressure at 200ºF. Coils shall be provided with a manual air vent fitting.
3. Drain pans: Primary condensate drain pans shall be single wall, heavy gauge stainless steel, sloped, and extended under the entire cooling coil. Drain pan shall be provided with fire retardant, closed cell foam insulation with a 25/50 flame spread and smoke developed rating per ASTM E-84 and UL 723, and an antimicrobial performance rating of 0, no observed growth, per ASTM G-21.
4. Filters: Provide unit with 2-inch pleated MERV 8 filters.
5. Valves: Provide hot water coil and chilled water coil with two-way modulating control valves, and integrate into the existing Building Energy Management System.
6. Controls: Provide control transformer, relays, and wall-mounted thermostat, and integrate into the existing Building Energy Management System to operate unit.

B. Ductless Split Air Conditioning Units: Provide a split air-conditioning system consisting of ductless units with wall-mounted evaporator section and associated decoration panel, wall-mounted controller/thermostat, remote controller, and outdoor condenser/compressor unit. The separate assemblies shall be designed to be used together and ratings shall be based on the use of the matched assemblies. The units shall be independently tested and listed with UL or ETL and shall bear the appropriate listing labels. The units have a minimum SEER of 21.4 in accordance with AHRI Standard 210. A full charge of the appropriate refrigerant, R410A shall be provided. Units shall meet or exceed all specified

and scheduled operating parameters. Manufacturer shall be as by Mitsubishi Model PKA and PUZ, or approved equal.

1. Indoor Unit: The indoor unit shall be completely factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, condensate drain pan, control circuit board and fan motor. The unit shall have a self-diagnostic function, time delay mechanism, an auto restart function, an emergency operation function and a test run switch. Indoor unit and refrigerant pipes shall be charged with dehydrated air, instead of refrigerant, before shipment from the factory.
   a. Cabinet: The casing shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation, and be wall mounted with vane setting for airflow direction control and auto fan speed mode.
   b. Mounting Provisions: Provide unit with all necessary brackets, isolators, and hardware to permit mounting as indicated.
   c. Fan and Motor: The evaporator fan shall be an assembly with a statically and dynamically balanced cross flow fan direct driven by a single motor with permanently lubricated bearings and thermally protected. The indoor fan shall consist of a minimum of three speeds. Unit shall have adjustable motorized louvers with the ability to change the airflow from horizontally and vertically.
   d. Filter: Return air shall be filtered by means of a washable filter with mildew proof resin and antibacterial treatment, easily removable without the use of tools and without removing the unit from its mounts. Contractor is responsible to ensure there is sufficient clearance to replace the filter while the unit is installed.
   e. Coil: The evaporator coil shall direct expansion type constructed of copper tubes expanded into aluminum fins to form a mechanical bond. The coils shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil with integral condensate pump and built in drain pan overflow safety alarm. A thermistor shall be located on the liquid and gas line.
   f. Control: The indoor unit shall include a self-diagnostic function. The microprocessor located in the remote 7-day programmable thermostat shall have the capability of sensing return air temperature and indoor coil temperature, receiving and processing commands from the controller, providing emergency operation and controlling the outdoor unit. The system shall be capable of automatically restarting when power is restored after power interruption. The system shall be integrated into the existing Building Energy Management System.
2. Outdoor Unit: The outdoor unit shall be designed specifically for use and packaged with the indoor units from the manufacturer. The outdoor unit shall interface with the indoor units and perform all functions necessary for operation. The outdoor unit shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory.
   a. Cabinet: The casing shall be fabricated of galvanized steel, bonderized and finished with a powder-coated baked enamel.

b. Fan and Motor: The unit shall be furnished with a direct drive propeller type fan and the unit shall have a horizontal discharge airflow. The motor shall have thermal overload protection and utilize permanently lubricated bearings. The fan motor shall be mounted for quiet operation. The fan shall be provided with a raised guard to prevent contact with moving parts.

c. Compressor: The compressors shall be of a high performance hermetically sealed scroll type, variable speed inverter driven, and one on/off control. Unit shall be capable of operating at a temperature range of 0ºF to 115ºF. The compressor shall be equipped with a high pressure switch, over- current relay, inverter overload protector, fusible plugs, and internal thermal overload and shall be mounted to avoid the transmission of vibration. The unit shall be equipped with wind baffles for low ambient operation and hail guard.

d. Coil: The condenser coil shall be of nonferrous construction with plate fins on copper tubing. The coil shall be protected with an integral metal guard. Refrigerant flow from the condenser shall be controlled by means of an electronic expansion valve.

e. Control: Operation of the outdoor unit shall be controlled by a remote wired, 7-day programmable controller, and integrated into the existing Building Energy Management System.

PART 3 - EXECUTION

3.01 INSTALLATION

A. ARHI 260 and 440, and as specified herein. Install system as indicated, in accordance with the requirements of ASHRAE 15, and as recommended in the manufacturer's installation and operational instructions.

1. General: Install equipment and components in a manner to insure proper and sequential operation of the equipment and equipment controls. Installation of equipment not covered herein or in manufacturer's instructions shall be installed as recommended by manufacturer's representative.
2. Provide proper foundations for mounting of equipment, accessories, appurtenances, piping and controls including, but not limited to, supports, vibration isolators, stands, guides, anchors, clamps and brackets. Foundations for equipment shall conform to equipment manufacturer's recommendation, unless otherwise indicated on drawings. Set anchor bolts and sleeves accurately using properly constructed templates. Anchor bolts shall be of adequate length and provided with welded on plates on the head end embedded in the concrete. Level equipment bases, using jacks or steel wedges, and neatly grout in with a nonshrinking type of grouting mortar. Locate equipment to allow working space for all necessary servicing such as shaft removal, disassembling compressor cylinders and pistons, replacing or adjusting drives, motors, or shaft seals, access to automatic controls, refrigerant charging, lubrication, oil draining and working clearance under overhead lines.

Provide electric isolation between dissimilar metals for the purpose of minimizing galvanic corrosion.

3. Electrical Work: Electric motor driven equipment specified herein shall be provided complete with motors, motor starters, and controls. Electrical equipment and wiring shall be in accordance with Division 26. Provide manual or automatic control and protective devices required for the operation herein specified and any control wiring required for controls and devices but not indicated.
4. Refrigerant Piping: In accordance with Section 23 23 13, “Refrigerant Piping & Specialties”.
5. Air Filters: Install air filters to allow access space for servicing the filters. Install filters with suitable sealing to prevent bypassing of air.

3.02 FIELD INSPECTION AND TESTS

A. Field Inspection: Prior to initial operation, inspect equipment installation for conformance with drawings and specifications.

B. Tests: All tests shall be performed by and everything required for testing shall be furnished by the Contractor, including personnel. Equipment and materials certified as having been successfully tested by the manufacturer in accordance with referenced specifications and standards will not require retesting before installation. Equipment and materials not tested at the place of manufacture shall be tested before or after installation, as applicable, where necessary to determine compliance with referenced specifications and standards.

1. Leak Testing: Upon completion of installation of the air conditioning equipment, test all factory and field installed refrigerant piping with an electronic type leak detector to acquire a leak tight refrigerant system. If leaks are detected at time of installation or during the guarantee period, remove the entire refrigerant charge from the system, correct the leaks, and retest the system.
2. Evacuation, Dehydration, and Charging: After field charged refrigerant system is found to be without leaks or after leaks have been repaired on field charged and factory charged systems, evacuate the system using a reliable gage and a vacuum pump capable of pulling a vacuum of at least 1 mm Hg absolute. Evacuate system in accordance with the triple evacuation and blotter method or, in accordance with equipment manufacturer's printed instructions. System leak testing, evacuation, dehydration, and charging with refrigerant shall comply with the requirements contained in ARI 260.
3. Startup and Operation Tests: Test the air conditioning systems and systems components for proper operation. Adjust safety and automatic control instruments as necessary to insure proper operation and sequence. The operational test shall be not less than 8 hours.
4. Performance Tests: Upon completion of evacuation, charging, startup, final leak testing, and proper adjustment of controls, systems shall be performance tested to demonstrate compliance with performance and capacity requirements. Test systems for not less than 8 hours, during which time hourly readings shall be recorded. At the end of the test

period, the readings shall be averaged and the average shall be considered to be the system performance.

C. Preliminary Tests: For each item of unitary air conditioning systems and its components, perform an operational test for a minimum period of four (4) hours.

D. Testing and Balancing: After preliminary tests, test, adjust, and balance the unitary air conditioning systems in accordance with Section 23 05 93, “Testing and Balancing Air and Water Systems”.

3.03 INSTRUCTION OF OPERATING PERSONNEL

A. Upon completion of the work, and acceptance of the installation, and at a time designated by the Owner, the services of a competent technician regularly employed or authorized by the manufacturer of the system shall be provided for instructing personnel in the proper operation, maintenance, safety and emergency procedures. The period of instruction shall be not less than four hours. The training shall be conducted at the job site during actual operation and coordinated with the Owner one week in advance.

END OF SECTION