SECTION 23 05 00 - BASIC HVAC REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements applicable to all Division 23 Sections. Also refer to Division 1 - General Requirements.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced herein and within each specification section.

1.2 SCOPE OF WORK

A. This Specification and the associated drawings govern the furnishing, installing, testing and placing into satisfactory operation the Mechanical Systems.

B. Each Contractor shall provide all new materials indicated on the drawings and/or in these specifications, and all items required to make the portion of the Mechanical Work a finished and working system.

C. All work will be awarded under a single General Contract. The division of work listed below is for the Contractor's convenience and lists normal breakdown of the work.

D. Scope of Work:

1. Plumbing Work shall include, but is not necessarily limited to:

a. Refer to Section 22 05 00.

2. Heating Work shall include, but is not necessarily limited to:

a. Furnish and install steam-to-water heat exchanger and all associated accessories, with connection to existing steam system.
b. Furnish and install a complete heating water system including pumps, piping, insulation, air control equipment, terminal heating equipment, and specialties. Make final connections to all coils, including those furnished by others.
c. Furnish and install a complete steam distribution system including piping, insulation, terminal heating equipment, traps, and specialties. Make final connections to all coils, including those furnished by others.
d. Furnish and install ceiling-mounted fan coil units/blower coil units/unit ventilators.
e. Furnish and install a condensate pump with fan coil unit/blower coils unit/unit ventilators as defined on drawings.
f. Furnish and install floor-mounted fan coil units/unit ventilators.
g. Furnish and install roof exhaust fans, downblast type.
h. Furnish and install cabinet heaters.
i. Furnish and install fin tube radiation heaters.
j. Furnish and install DX mini-split system where indicated on plan.
k. Furnish and install refrigerant piping, accessories, and final charge of refrigerant.

l. Furnish and install firestopping systems for penetrations of fire-rated construction associated with this Contractor's work.

3. Air Conditioning and Ventilating Work shall include, but is not necessarily limited to:

a. Furnish and install roof-mounted air-cooled condensing units and curbs.
b. Furnish and install complete supply air ductwork systems including all fittings, insulation, and outlets.
c. Furnish and install complete return/exhaust air ductwork systems including all fittings, insulation, and inlets.
d. Furnish and install restroom exhaust fans connected to existing duct systems.
e. Furnish and install all temperature control systems.
f. Furnish and install roof relied ventilators, relief air duct and relief air grilles.
g. Furnish and install all fire dampers where noted on plan and as required by code.
h. Furnish and install firestopping systems for penetrations of fire-rated construction associated with this Contractor's work.
i. Furnish and install Variable Refrigerant Flow (VRF) air conditioning system.
j. Furnish and intall packaged rooftop dedicated outdoor air unit complete with curb.

4. Temperature Control Work shall include, but is not necessarily limited to:

a. Furnish and install a complete temperature control system as specified in Section 23 09 00.
b. Temperature control system shall consist of a full Direct Digital Control (DDC) system including all accessories, sensors, and programming.
c. Furnish automatic control valves and dampers for installation by others.
d. Coordinate installation with JACE system specific to Rockford Public Schools.
e. Furnish and install firestopping systems for penetrations of fire-rated construction associated with this Contractor's work.

5. Testing, Adjusting, and Balancing Work shall include, but is not necessarily limited to:

a. Furnish complete testing, adjusting, and balancing as specified in Section 23 05 93, including, but not limited to, air systems, hydronic systems, plumbing systems, and verification of control systems.

1.3 WORK SEQUENCE

A. All work that will produce excessive noise or interference with normal building operations for a school, as determined by the Owner, shall be scheduled with the Owner. It may be necessary to schedule such work during unoccupied hours and around the school schedule. The Owner reserves the right to determine when restricted construction hours will be required.

B. Schedule overtime for the following work:

1. Work in mechanical rooms when school is in session.
2. Work on roof when school is in session.
3. Specific tunnel work when school is in session.

1.4 ALTERNATES

A.

1.5 DIVISION OF WORK BETWEEN MECHANICAL, ELECTRICAL & CONTROL CONTRACTORS

A. Definitions:

1. "Mechanical Contractors" refers to the following:

    a. Plumbing Contractor.
    b. Heating Contractor.
    c. Air Conditioning and Ventilating Contractor.
    d. Temperature Control Contractor.
    e. Testing, Adjusting, and Balancing Contractor.

2. Motor Control Wiring: The wiring associated with the remote operation of the magnetic coils of magnetic motor starters or relays, or the wiring that permits direct cycling of motors by means of devices in series with the motor power wiring. In the latter case the devices are usually single phase and are usually connected to the motor power wiring through a manual motor starter having "Manual-Off-Auto" provisions.
3. Control devices such as start-stop push buttons, thermostats, pressure switches, flow switches, relays, etc., generally represent the types of equipment associated with motor control wiring.
4. Motor control wiring is single phase and usually 120 volts. In some instances, the voltage will be the same as the motor power wiring. Generally, where the motor power wiring exceeds 120 volts, a control transformer is used to give a control voltage of 120 volts.
5. Temperature Control Wiring: The wiring associated with the operation of a motorized damper, solenoid valve or motorized valve, etc., either modulating or two-position, as opposed to wiring which directly powers or controls a motor used to drive equipment such as fans, pumps, etc.

    a. This wiring will be from a 120 volt source and may continue as 120 volt, or be reduced in voltage (24 volt) in which case a control transformer shall be furnished as part of the temperature control wiring.

6. Control Motor: An electric device used to operate dampers, valves, etc. It may be two-position or modulating. Conventional characteristics of such a motor are 24 volts, 60 cycles, 1 phase, although other voltages may be encountered.
7. Voltage is generally specified and scheduled as distribution voltage. Motor submittals may be based on utilization voltage if it corresponds to the correct distribution voltage.

| Distribution/Nominal Voltage | Utilization Voltage |
|---|---|
| 120 | 115 |
| 208 | 200 |
| 240 | 230 |
| 277 | 265 |
| 480 | 460 |

B. General:

1. The purpose of these Specifications is to outline the Electrical and Mechanical Contractor's responsibilities related to electrical work required for items such as temperature controls, mechanical equipment, fans, chillers, compressors and the like. The exact wiring requirements for much of the equipment cannot be determined until the systems have been selected and submittals reviewed. Therefore, the electrical drawings show only known wiring related to such items. All wiring not shown on the electrical drawings, but required for mechanical systems, is the responsibility of the Mechanical Contractor.
2. Where the drawings require the Electrical Contractor to wire between equipment furnished by the Mechanical Contractor, such wiring shall terminate at terminals provided in the equipment. The Mechanical Contractor shall provide complete electrical power/controls wiring diagrams and supervision to the Electrical Contractor and designate the terminal numbers for correct wiring.
3. All electrical work shall conform to the National Electrical Code. All provisions of the Electrical Specifications concerning wiring, protection, etc., apply to wiring provided by the Mechanical Contractor unless noted otherwise.
4. All Contractors shall establish utility elevations prior to fabrication and shall coordinate their material and equipment with other trades. When a conflict arises, priority is as follows:

    a. Light fixtures.
    b. Gravity flow piping, including steam and condensate.
    c. Electrical busduct.
    d. Sheet metal.
    e. Electrical cable trays, including access space.
    f. Sprinkler piping and other piping.
    g. Electrical conduits and wireway.

C. Mechanical Contractor's Responsibility:

1. Assumes responsibility for internal wiring of all equipment provided by the Mechanical Contractor, for example:

    a. Chillers.
    b. Computer Room Air Conditioning Units.
    c. Condensate Return Stations.
    d. Condensing Units.
    e. Makeup Air Units.
    f. Gas Trains.
    g. Package Air Handling Units.
    h. Packaged Rooftop Units.

2. Assumes all responsibility for the Temperature Control wiring, when the Temperature Control Contractor is a Subcontractor to the Mechanical Contractor.
3. Temperature Control Contractor's Responsibility:

    a. Wiring of all devices needed to make the Temperature Control System functional.

b. Verifying any control wiring on the electrical drawings as being by the Electrical Contractor. All wiring required for the Control System, but not shown on the electrical drawings, is the responsibility of the Temperature Control Subcontractor .
c. Coordinating equipment locations (such as relays, transformers, etc.) with the Electrical Contractor, where wiring of the equipment is by the Electrical Contractor.

4. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

D. Electrical Contractor's Responsibility:

1. Provides all combination starters, manual starters and disconnect devices shown on the Electrical Drawings or indicated to be by the Electrical Contractor on the Mechanical Drawings or Specifications.
2. Installs and wires all remote control devices furnished by the Mechanical Contractor or Temperature Control Subcontractor when so noted on the Electrical Drawings.
3. Provides motor control and temperature control wiring, where so noted on the drawings.
4. Furnishes, installs and connects all relays, etc., for automatic shutdown of certain fans upon actuation of the Fire Alarm System as indicated and specified in Division 28.
5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.6 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, medical gas systems, hydronic piping, steam and steam condensate piping, and any item that may impact coordination with other disciplines.
b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5" (40 mm) and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5" (40 mm) and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
d. Maintenance clearances and code-required dedicated space shall be included.
e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. Spaces with open/cloud ceiling architecture shall indicate the overhead utilities and locate equipment as required to maintain clearance above lights. The intent for the installation is to maintain a maximum allowable vertical clearance and an organized/clean manner in the horizontal. Notify Architect/Engineer of the maximum clearance which can be maintained. Failure to comply will result in modifications with no cost to Owner.

    a. In cloud ceiling architecture, when open cabling/wire and/or cable tray crosses gaps between ceiling clouds and/or walls, cabling is to transition to conduits to span the gaps in order to conceal cabling from below.

3. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.
2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the Mechanical Contractor.

    a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. IMEG will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all contractors participating in the coordination process and the Owner.

    a. Scale of drawings:

        1) General plans: 1/4 Inch = 1'-0" (minimum).
        2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).
        3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).
        4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1'-0" (minimum).
        5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.
3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.
4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

D. General:

1. Coordination drawing files shall be made available to the A/E and Owner's Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.
2. A plotted set of coordination drawings shall be available at the project site.
3. Coordination drawings are not shop drawings and shall not be submitted as such.
4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in the bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.
5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.
6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.
7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.
8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.
9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

    a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.
    b. Potential layout changes shall be made to avoid additional access panels.
    c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.
    d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.
    e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain sign off of the drawings by all contractors prior to installing any of the components.
11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.
12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.7 QUALITY ASSURANCE

A. Contractor's Responsibility Prior to Submitting Pricing Data:

1. The Contractor is responsible for constructing complete and operating systems. The Contractor acknowledges and understands that the Contract Documents are a two-dimensional representation of a three-dimensional object, subject to human interpretation. This representation may include imperfect data, interpreted codes, utility guidelines, three-dimensional conflicts, and required field coordination items. Such deficiencies can be corrected when identified prior to ordering material and starting installation. The Contractor agrees to carefully study and compare the individual Contract Documents and report at once in writing to the Design Team any deficiencies the Contractor may discover. The Contractor further agrees to require each subcontractor to likewise study the documents and report at once any deficiencies discovered.
2. The Contractor shall resolve all reported deficiencies with the Architect/Engineer prior to awarding any subcontracts, ordering material, or starting any work with the Contractor's own employees. Any work performed prior to receipt of instructions from the Design Team will be done at the Contractor's risk.

B. Qualifications:

1. Only products of reputable manufacturers are acceptable.
2. All Contractors and subcontractors shall employ only workers skilled in their trades.

C. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of the Rockford, Illinois Codes, Laws, Ordinances and other regulations having jurisdiction.
2. Conform to all State Codes.
3. If there is a discrepancy between the codes and regulations and these specifications, the Architect/Engineer shall determine the method or equipment used.
4. If the Contractor notes, at the time of bidding, that any parts of the drawings or specifications do not comply with the codes or regulations, Contractor shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time for this procedure, Contractor shall submit with the proposal a separate price to make the system comply with the codes and regulations.
5. All changes to the system made after letting of the contract, to comply with codes or requirements of Inspectors, shall be made by the Contractor without cost to the Owner.
6. If there is a discrepancy between manufacturer's recommendations and these specifications, the manufacturer's recommendations shall govern.
7. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Contractor is responsible for providing this guarding if it is not provided with the equipment supplied.

D. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.
2. Abide by all laws, regulations, ordinances, and other rules of the State or Political Subdivision where the work is done, or as required by any duly constituted public authority.

3. Pay all charges for permits or licenses.
4. Pay all fees and taxes imposed by the State, Municipal and/or other regulatory bodies.
5. Pay all charges arising out of required inspections by an authorized body.
6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized agency/consultant.

E. Utility Company Requirements:

1. Secure from the appropriate private or public utility company all applicable requirements.
2. Comply with all utility company requirements.
3. Make application for and pay for service connections, such as gas.
4. Make application for and pay for all meters and metering systems required by the utility company.

F. Examination of Drawings:

1. The drawings for the mechanical work are completely diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment, outlets, etc., and the approximate sizes of equipment.
2. Contractor shall determine the exact locations of equipment and rough-ins, and the exact routing of pipes and ducts to best fit the layout of the job.
3. Scaling of the drawings is not sufficient or accurate for determining these locations.
4. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.
5. Because of the scale of the drawings, certain basic items, such as fittings, boxes, valves, unions, etc., may not be shown, but where required by other sections of the specifications or required for proper installation of the work, such items shall be furnished and installed.
6. If an item is either on the drawings or in the specifications, it shall be included in this contract.
7. Determination of quantities of material and equipment required shall be made by the Contractor from the documents. Where discrepancies arise between drawings, schedules and/or specifications, the greater number shall govern.
8. Where used in mechanical documents, the word "furnish" shall mean supply for use, the word "install" shall mean connect complete and ready for operation, and the word "provide" shall mean to supply for use and connect complete and ready for operation.

    a. Any item listed as furnished shall also be installed, unless otherwise noted.
    b. Any item listed as installed shall also be furnished, unless otherwise noted.

G. Field Measurements:

1. Verify all pertinent dimensions at the job site before ordering any materials or fabricating any supports, pipes or ducts.

H. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.
2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.

3. Upon request for electronic media, the Contractor shall complete and return a signed "Electronic File Transmittal" form provided by IMEG.
4. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.
5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.
6. The drawings prepared by IMEG for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.
7. The use of these CAD documents by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.
8. The information is provided to expedite the project and assist the Contractor with no guarantee by IMEG as to the accuracy or correctness of the information provided. IMEG accepts no responsibility or liability for the Contractor's use of these documents.

1.8 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals List:

| Referenced Specification Section | Submittal Item |
|---|---|
| 23 05 00 | Owner Training Agenda |
| 23 05 03 | Fire Seal Systems |
| 23 05 13 | Motors |
| 23 05 93 | Testing, Adjusting, and Balancing |
| 23 09 00 | Controls |
| 23 09 13 | Instrumentation |
| 23 21 23 | HVAC Pumps |
| 23 25 00 | Chemical Treatment Systems |
| 23 31 00 | Ductwork Layout Drawings |
| 23 33 00 | Fire Dampers |
| 23 34 16 | Centrifugal Fans |
| 23 34 23 | Power Ventilators |
| 23 37 00 | Grilles, Registers, and Diffusers |
| 23 37 00 | Louvers |
| 23 57 00 | Heat Exchangers |
| 23 64 30 | Air Cooled Water Chillers |
| 23 72 00 | Energy Recovery Devices |
| 23 73 23 | Custom Air Handling Units |
| 23 74 13 | Rooftop Modular Air Handling Units |
| 23 74 16.12 | Packaged Rooftop Air Conditioning Units - 25T and Below |
| 23 74 16.13 | Packaged Rooftop Air Conditioning Units - Above 25T |
| 23 74 23.13 | Gas Fired Make-Up Air Units |
| 23 81 26 | Split System Air Conditioning Units |

| | |
|---|---|
| 23 82 00 | Terminal Heat Transfer Equipment |
| 23 82 16 | Coils |

B. General Submittal Procedures: In addition to the provisions of Division 1, the following are required:

1. Transmittal: Each transmittal shall include the following:

   a. Date
   b. Project title and number
   c. Contractor's name and address
   d. Division of work (e.g., plumbing, heating, ventilating, etc.)
   e. Description of items submitted and relevant specification number
   f. Notations of deviations from the contract documents
   g. Other pertinent data

2. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

   a. Date
   b. Project title and number
   c. Architect/Engineer
   d. Contractor and subcontractors' names and addresses
   e. Supplier and manufacturer's names and addresses
   f. Division of work (e.g., plumbing, heating, ventilating, etc.)
   g. Description of item submitted (using project nomenclature) and relevant specification number
   h. Notations of deviations from the contract documents
   i. Other pertinent data
   j. Provide space for Contractor's review stamps

3. Composition:

   a. Submittals shall be submitted using specification sections and the project nomenclature for each item.
   b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).
   c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

4. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; electrical power criteria (e.g., voltage, phase, amps, horsepower, kW, etc.) wiring and control diagrams; Short Circuit Current Rating (SCCR); dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.
5. Contractor's Approval Stamp:

a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.
b. Unstamped submittals will be rejected.
c. The Contractor's review shall include, but not be limited to, verification of the following:

1) Only approved manufacturers are used.
2) Addenda items have been incorporated.
3) Catalog numbers and options match those specified.
4) Performance data matches that specified.
5) Electrical characteristics and loads match those specified.
6) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
7) Dimensions and service clearances are suitable for the intended location.
8) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.
9) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

d. The Contractor shall review, stamp and approve all subcontractors' submittals as described above.
e. The Contractor's approval stamp is required on all submittals. Approval will indicate the Contractor's review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.

6. Submittal Identification and Markings:

a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.
b. The Contractor shall clearly indicate the size, finish, material, etc.
c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.
d. All marks and identifications on the submittals shall be unambiguous.

7. Schedule submittals to expedite the project. Coordinate submission of related items.
8. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.
9. Reproduction of contract documents alone is not acceptable for submittals.
10. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.
11. Submittals not required by the contract documents may be returned without review.
12. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.

13. Submittals shall be reviewed and approved by the Architect/Engineer before releasing any equipment for manufacture or shipment.
14. Contractor's responsibility for errors, omissions or deviation from the contract documents in submittals is not relieved by the Architect/Engineer's approval.

C. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. Submittal file name: 23 XX XX.description.YYYYMMDD
    b. Transmittal file name: 23 XX XX.description.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.

1.9 SCHEDULE OF VALUES

A. The requirements herein are in addition to the provisions of Division 1.

B. Format:

1. Use AIA Document Continuation Sheets G703 or another similar form approved by the Owner and Architect/Engineer.
2. Submit in Excel format.
3. Support values given with substantiating data.

C. Preparation:

1. Itemize work required by each specification section and list all providers. All work provided by subcontractors and major suppliers shall be listed on the Schedule of Values. List each subcontractor and supplier by company name.
2. Break down all costs into:

    a. Material: Delivered cost of product with taxes paid.
    b. Labor: Labor cost, excluding overhead and profit.

3. Itemize the cost for each of the following:

    a. Overhead and profit.
    b. Bonds.
    c. Insurance.

d. General Requirements: Itemize all requirements.

4. For each line item having an installed cost of more than $5,000, break down costs to list major products or operations under each item. At a minimum, provide material and labor cost line items for the following:

a. Each piece of equipment requiring shop drawings (e.g., each air handling unit, pump, exhaust fan, etc.). Use the equipment nomenclature (AHU-1, P-1, EF-1, etc.) on the Schedule of Values.
b. Each type of small unitary equipment (e.g., FCUs, UHs, CABs, etc.). Multiple units of the same type can be listed together, provided quantities are also listed so unit costs can be determined.
c. Each piping system (chilled water, heating water, steam, condensate, etc.). In addition, for larger projects, break down the material and labor for each piping system based on geography (building, floor, and/or wing).
d. Each duct system (supply, return, relief, outside air, etc.) listed separately for each unit they serve (AHU-1 supply air ductwork, AHU-1 return air ductwork, etc.).
e. Pipe insulation with separate material and labor line items for each piping system listed above.
f. Duct insulation with separate material and labor line items for each duct system listed above.
g. Temperature controls broken down into material and labor for the following:

1) Engineering
2) Controllers, devices, sensors, etc.
3) Control valves
4) Control dampers
5) Conduit
6) Wiring
7) Programming
8) Commissioning

h. Air balancing
i. Water balancing
j. Record drawings
k. Punchlist and closeout

D. Update Schedule of Values when:

1. Indicated by Architect/Engineer.
2. Change of subcontractor or supplier occurs.
3. Change of product or equipment occurs.

1.10 CHANGE ORDERS

A. A detailed material and labor takeoff shall be prepared for each change order, along with labor rates and markup percentages. Change orders with inadequate breakdown will be rejected.

B. Change order work shall not proceed until authorized.

1.11 EQUIPMENT SUPPLIERS' INSPECTION

A. The following equipment shall not be placed in operation until a competent installation and service representative of the manufacturer has inspected the installation and certified that the equipment is properly installed, adjusted and lubricated; that preliminary operating instructions have been given; and that the equipment is ready for operation:

1. Air Cooled Chiller
2. Base Mounted Pumps
3. Computer Room Units
4. Condensing Units
5. Gas Fired Makeup Air Units
6. Fire Seal Systems
7. Water Chillers

B. Contractor shall arrange for and obtain supplier's on-site inspection(s) at proper time(s) to assure each phase of equipment installation and/or connection is in accordance with the manufacturer's instructions.

C. Submit copies of start-up reports to the Architect/Engineer and include copies of Owner's Operation and Maintenance Manuals.

1.12 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage. Keep materials clean, dry and free from harmful conditions. Immediately remove any materials that become wet or that are suspected of becoming contaminated with mold or other organisms.

B. Keep all bearings properly lubricated and all belts properly tensioned and aligned.

C. Coordinate the installation of heavy and large equipment with the General Contractor and/or Owner. If the Mechanical Contractor does not have prior documented experience in rigging and lifting similar equipment, he/she shall contract with a qualified lifting and rigging service that has similar documented experience. Follow all equipment lifting and support guidelines for handling and moving.

D. Contractor is responsible for moving equipment into the building and/or site. Contractor shall review site prior to bid for path locations and any required building modifications to allow movement of equipment. Contractor shall coordinate the work with other trades.

1.13 NETWORK / INTERNET CONNECTED EQUIPMENT

A. These specifications may require certain equipment or systems to have network, Internet and/or remote access capability ("Network Capability"). Any requirement for Network Capability shall be interpreted only as a functional capability and is not to be construed as authority to connect or enable any Network Capability. Network Capability may only be connected or enabled with the express written consent of the Owner.

1.14 WARRANTY

A. Provide one-year warranty, unless otherwise noted, to the Owner for all fixtures, equipment, materials, and workmanship.

B. The warranty period for all work in this Division of the specifications shall commence on the date of final acceptance, unless a whole or partial system or any separate piece of equipment or component is put into use for the benefit of any party other than the installing contractor with prior written authorization. In this instance, the warranty period shall commence on the date when such whole system, partial system or separate piece of equipment or component is placed in operation and accepted in writing by the Owner.

C. Warranty requirements shall extend to correction, without cost to the Owner, of all Work found to be defective or nonconforming to the contract documents. The Contractor shall bear the cost of correcting all damage resulting from defects or nonconformance with contract documents.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or the employees and subconsultants at a construction site, shall relieve the Contractor and other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 EXCAVATION, FILL, BACKFILL, COMPACTION

A. General:

1. Prior to the commencement of any excavation or digging, the Contractor shall verify all underground utilities with the regional utility locator. Provide prior notice to the locator before excavations. Contact information for most regional utility locaters can be found at the following website (https://call811.com/) or by calling 811.
2. The Contractor shall do all excavating, filling, backfilling and compacting associated with the work.

B. Excavation:

1. Make all excavations to accurate, solid, undisturbed earth, and to proper dimensions.

2. Where excavations are made in error below foundations, concrete of same strength as specified for the foundations or thoroughly compacted sand-gravel fill, as determined by the Architect/Engineer, shall be placed in such excess excavations. Place thoroughly compacted, clean, stable fill in excess excavations under slabs on grade, at the Contractor's expense.
3. Trim bottom and sides of excavations to grades required for foundations.
4. Protect excavations against frost and freezing.
5. Take care in excavating not to damage surrounding structures, equipment, or buried pipe. Do not undermine footing or foundation.
6. Perform all trenching in a manner to prevent cave-ins and risk to workers.
7. Where original surface is pavement or concrete, the surface shall be saw cut to provide clean edges and assist in the surface restoration.
8. Where satisfactory bearing soil for foundations is not found at the indicated levels, the Architect/Engineer or their representative shall be notified immediately, and no further work shall be done until further instructions are given by the Architect/Engineer or their representative.

C. Dewatering:

1. Contractor shall furnish, install, operate, and remove all dewatering pumps and pipes needed to keep trenches and pits free of water.

D. Underground Obstructions:

1. Known underground piping, foundations, and other obstructions in the vicinity of construction are shown on the drawings. Use great care in making installations near underground obstruction.
2. If objects not shown on the drawings are encountered, remove, relocate, or perform extra work as directed by the Architect/Engineer.

E. Fill and Backfilling:

1. No rubbish or waste material is permitted for fill or backfill.
2. Provide all necessary sand and/or CA6 for backfilling.
3. Native soil materials may be used as backfill if approved by the Geotechnical Engineer.
4. Dispose of the excess excavated earth as directed.
5. Backfill materials (native soil material, sand, and/or CA6) shall be suitable for required compaction, clean and free of perishable materials and stones greater than 4 inches (100 mm) in diameter. Water shall not be permitted to rise in unbackfilled trenches. No material shall be used for backfilling that contains frozen earth, debris, or earth with a high void content.
6. Backfill all trenches and excavations immediately after installing pipes or removal of forms, unless other protection is provided.
7. Around piers and isolated foundations and structures, backfill and fill shall be placed and consolidated simultaneously on all sides to prevent wedge action and displacement. Fill and backfill materials shall be spread in 6 inch (150 mm) uniform horizontal layers with each layer compacted separately to required density.
8. Lay all piping on a compacted bed of CA6 at least 3 inches (80 mm) deep. Backfill around pipes with CA6, 6 inch (150 mm) layers, and compact each layer.

9. Use native soil material (if approved), sand, or CA6 for backfill up to grade for all piping under slabs or paved areas. All other piping shall have sand or CA6 backfill to 6 inches (150 mm) above the top of the pipe.
10. Place all backfill above the sand/CA6 in uniform layers not exceeding 6 inches (150 mm) deep. Each layer shall be placed, then carefully and uniformly tamped, to eliminate lateral or vertical displacement.
11. Where the fill and backfill will ultimately be under a building, floor or paving, each layer of fill shall be compacted to 95% of the maximum density determined by AASHTO Designation T-99 or ASTM Designation D-698. Moisture content of soil at time of compaction shall not exceed plus or minus 2% of optimum moisture content determined by AASHTO T-99 or ASTM D-698 test.

F. Surface Restoration:

1. Where trenches are cut through graded, planted, or landscaped areas, the areas shall be restored to the original condition. Replace all planting removed or damaged to its original condition. A minimum of 6 inches (150 mm) of topsoil shall be applied where disturbed areas are to be seeded or sodded.
2. Concrete or asphalt type pavement, seal coat, rock, gravel or earth surfaces removed or damaged shall be replaced with comparable materials and restored to original condition.

3.3 ARCHITECT/ENGINEER OBSERVATION OF WORK

A. The Contractor shall provide seven (7) calendar days' notice to the Architect/Engineer prior to:

1. Installing hard or suspended ceilings and soffits.

B. The Architect/Engineer will have the opportunity to review the installation and provide a written report noting deficiencies requiring correction. The Contractor's schedule shall account for these reviews and show them as line items in the approved schedule.

C. Above-Ceiling Final Observation

1. All work above the ceilings must be complete prior to the Architect/Engineer's review. This includes, but is not limited to:

a. Pipe insulation is installed and fully sealed.
b. Pipe and duct wall penetrations are sealed.
c. Pipe identification and valve tags are installed.
d. Main, branch and flexible ducts are installed.
e. Diffusers, registers and grilles are installed and connected to ductwork.
f. Terminal air box reheat coil piping or wiring is complete.
g. Terminal air box control wiring is complete and all control boxes are closed.

2. In order to prevent the Above-Ceiling Final Observation from occurring too early, the Contractor shall review the status of the work and certify, in writing, that the work is ready for the Above-Ceiling Final Observation.
3. It is understood that if the Architect/Engineer finds the ceilings have been installed prior to this review and prior to 7 days elapsing, the Architect/Engineer may not recommend further payments to the contractor until such time as full access has been provided.

3.4 PROJECT CLOSEOUT

A. The following paragraphs supplement the requirements of Division 1.

B. Final Jobsite Observation:

1. In order to prevent the Final Jobsite Observation from occurring too early, the Contractor is required to review the completion status of the project and certify that the job is ready for the final jobsite observation.
2. Attached to the end of this section is a typical list of items that represent the degree of job completeness expected prior to requesting a review.
3. Upon Contractor certification that the project is complete and ready for a final observation, the Contractor shall sign the attached certification and return it to the Architect/Engineer so that the final observation can be scheduled.
4. It is understood that if the Architect/Engineer finds the job not ready for the final observation and that additional trips and observations are required to bring the project to completion, the costs incurred by the Architect/Engineer's additional time and expenses will be deducted from the Contractor's contract retainage prior to final payment at the completion of the job.

C. Before final payment is authorized, this Contractor must submit the following:

1. Operation and maintenance manuals with copies of approved shop drawings.
2. Record documents including marked-up drawings and specifications.
3. A report documenting the instructions given to the Owner's representatives complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of This Contractor and shall be signed by the Owner's representatives.
4. Start-up reports on all equipment requiring a factory installation inspection or start-up.
5. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site; receipt by Architect/Engineer required prior to final payment approval.

3.5 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for Architect/Engineer's review and approval. The electronic copy shall be corrected as required to address the Architect/Engineer's comments. Once corrected, electronic copies and paper copies shall be distributed as directed by the Architect/Engineer.
2. Approved O&M manuals shall be completed and in the Owner's possession prior to Owner's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Email the O&M manual as attachments to all parties designated by the Architect/Engineer.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. O&M file name: O&M.div23.contractor.YYYYMMDD
    b. Transmittal file name: O&Mtransmittal.div23.contractor.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.
6. Provide the Owner with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title "Operation and Maintenance Instructions", title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.
7. All text shall be searchable.
8. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, Contractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.
2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.
3. Copies of all final approved shop drawings and submittals. Include Architect's/Engineer's shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.
4. Refer to Section 23 09 00 for additional requirements for Temperature Control submittals.
5. Copy of final approved test and balance reports.
6. Copies of all factory inspections and/or equipment startup reports.
7. Copies of warranties.
8. Schematic electrical power/controls wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.
9. Dimensional drawings of equipment.
10. Capacities and utility consumption of equipment.
11. Detailed parts lists with lists of suppliers.
12. Operating procedures for each system.
13. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.
14. Repair procedures for major components.
15. List of lubricants in all equipment and recommended frequency of lubrication.
16. Instruction books, cards, and manuals furnished with the equipment.

## 3.6 INSTRUCTING THE OWNER'S REPRESENTATIVES

A. Adequately instruct the Owner's designated representatives in the maintenance, care, and operation of all systems installed under this contract.

B. Provide verbal and written instructions to the Owner's representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. The instructions shall include:

1. Explanation of all system flow diagrams.
2. Explanation of all air handling systems.
3. Temperature control system operation including calibration, adjustment and proper operating conditions of all sensors.
4. Maintenance of equipment.
5. Start-up procedures for all major equipment.
6. Explanation of seasonal system changes.
7. Description of emergency system operation.

D. Notify the Architect/Engineer of the time and place for the verbal instructions to be given to the Owner's representative so a representative can attend if desired.

E. Minimum hours of instruction for each item shall be:

1. Heating Water System - 2 hours.
2. Chilled Water System - 2 hours.
3. Steam/Condensate System - 2 hours.
4. Refrigeration System - 1 hours.
5. Chemical Treatment System - As defined in Section 23 25 00.
6. Air Handling System(s) - 8 hours.
7. Exhaust System(s) - 1 hours.
8. Temperature Controls - As defined in Section 23 09 00.

F. The Contractor shall prepare a detailed, written training agenda and submit it to the Architect/Engineer a minimum of two weeks prior to the formal training for approval. The written agenda shall include specific training points within the items described above. For example: how to adjust setpoints, troubleshooting, proper start-up, proper shut-down, seasonal changes, draining, venting, changing filters, changing belts, etc. Failure to provide and follow an approved training agenda may result in additional training required at the expense of the Contractor.

G. Operating Instructions:

1. Contractor is responsible for all instructions to the Owner's representatives for the mechanical and control systems.
2. If the Contractor does not have staff that can adequately provide the required instructions the Contractor shall include in the bid an adequate amount to reimburse the Owner for the Architect/Engineer to perform these services.

## 3.7 SYSTEM STARTING AND ADJUSTING

A. The mechanical systems shall be complete and operating. System startup, testing, adjusting, and balancing to obtain satisfactory system performance is the responsibility of the Contractor. This includes calibration and adjustments of all controls, noise level adjustments and final comfort adjustments as required.

B. Complete all manufacturer-recommended startup procedures and checklists to verify proper motor rotation, electrical power voltage is within equipment limitations, equipment controls maintain pressures and temperatures within acceptable ranges, all filters and protective guards are in-place, acceptable access is provided for maintenance and servicing, and equipment operation does not pose a danger to personnel or property.

C. Operate all HVAC systems continuously for at least one week prior to occupancy to bring construction materials to suitable moisture levels. Areas with mechanical cooling shall be maintained below 60% RH.

D. Contractor shall adjust the mechanical systems and controls at season changes during the one year warranty period, as required, to provide satisfactory operation and to prove performance of all systems in all seasons.

E. All operating conditions and control sequences shall be tested during the start-up period. Test all interlocks, safety shutdowns, controls, and alarms.

F. The Contractor, subcontractors, and equipment suppliers shall have skilled technicians to ensure that all systems perform properly. If the Architect/Engineer is requested to visit the job site for trouble shooting, assisting in start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period, through no fault of the design; the Contractor shall reimburse the Owner on a time and materials basis for services rendered at the Architect/Engineer's standard hourly rates in effect when the services are requested. The Contractor shall pay the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

## 3.8 RECORD DOCUMENTS

A. The following paragraphs supplement Division 1 requirements.

B. Maintain at the job site a separate and complete set of mechanical drawings and specifications with all changes made to the systems clearly and permanently marked in complete detail.

C. Mark drawings to indicate revisions to piping and ductwork, size and location, both exterior and interior; including locations of coils, dampers, other control devices, filters, and other units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned from column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (e.g., traps, strainers, expansion compensators, tanks, etc.); Change Orders; concealed control system devices.

D. Refer to Section 23 09 00 for additional requirements for Temperature Control documents.

E. Mark specifications to show approved substitutions; Change Orders, and actual equipment and materials used.

F. Record changes daily and keep the marked drawings available for the Architect/Engineer's examination at any normal work time.

G. Upon completing the job, and before final payment is made, give the marked-up drawings to the Architect/Engineer.

3.9 PAINTING

A. Paint all equipment that is marred or damaged prior to the Owner's acceptance. Paint and color shall match original equipment paint and shall be obtained from the equipment supplier if available.

B. Equipment cabinets, casings, covers, metal jackets, etc., in equipment rooms or concealed spaces, shall be furnished in standard or prime finish, free from scratches, abrasions, chips, etc.

C. Equipment in occupied spaces, or if standard to the unit, shall have a baked primer with baked enamel finish coat free from scratches, abrasions, chips, etc. If color option is specified or is standard to the unit, this Contractor shall, before ordering, verify with the Architect/Engineer the color preference and furnish this color.

D. Paint all outdoor uninsulated steel piping the color selected by Owner or Architect/Engineer.

E. Paint all outdoor exposed natural gas piping the color selected by Owner or Architect/Engineer. All horizontal gas piping on the roof shall be primarily white. All vertical piping offset on roof shall match the wall color, verify with architect/engineer.

3.10 ADJUST AND CLEAN

A. Thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project. Clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from all equipment.

B. Clean all drain pans and areas where moisture is present. Immediately report any mold, biological growth, or water damage.

C. Remove all rust, scale, dirt, oils, stickers and thoroughly clean exterior of all exposed bare metal ductwork, piping, hangers, and accessories.

D. Remove all rubbish, debris, etc., accumulated during construction from the premises.

3.11 SPECIAL REQUIREMENTS

A. Contractor shall coordinate the installation of all equipment, valves, dampers, operators, etc., with other trades to maintain clear access area for servicing.

B. All equipment shall be installed in such a way to maximize access to parts needing service or maintenance. Review the final field location, placement, and orientation of equipment with the Owner's designated representative prior to setting equipment.

C. Installation of equipment or devices without regard to coordination of access requirements and confirmation with the Owner's designated representative will result in removal and reinstallation of the equipment at the Contractor's expense.

3.12 IAQ MAINTENANCE FOR OCCUPIED FACILITIES UNDER CONSTRUCTION

A. Contractors shall make all reasonable efforts to prevent construction activities from affecting the air quality of the occupied areas of the building or outdoor areas near the building. These measures shall include, but not be limited to:

1. All contractors shall endeavor to minimize the amount of contaminants generated during construction. Methods to be employed shall include, but not be limited to:

    a. Minimizing the amount of dust generated.
    b. Reducing solvent fumes and VOC emissions.
    c. Maintain good housekeeping practices, including sweeping and periodic dust and debris removal. There should be no visible haze in the air.
    d. Protect stored on-site and installed absorptive materials from moisture damage.

2. Request that the Owner designate an IAQ representative.
3. Review and receive approval from the Owner's IAQ representative for all IAQ-related construction activities and negative pressure containment plans.
4. Inform the IAQ representative of all conditions that could adversely impact IAQ, including operations that will produce higher than normal dust production or odors.
5. Schedule activities that may cause IAQ conditions that are not acceptable to the Owner's IAQ representative during unoccupied periods.
6. Request copies of and follow all of the Owner's IAQ and infection control policies.
7. Unless no other access is possible, the entrance to construction site shall not be through the existing facility.
8. To minimize growth of infectious organisms, do not permit damp areas in or near the construction area to remain for over 24 hours.
9. In addition to the criteria above, provide measures as recommended in the SMACNA "IAQ Guidelines for Occupied Buildings Under Construction".
10. If permanently installed air handlers are used to serve both construction and occupied areas, all return grilles throughout construction areas shall be sealed to prevent air from construction areas being supplied to occupied areas.
11. If permanently installed air handlers are used during construction to serve only construction areas and do not supply air to adjacent occupied areas, MERV 8 filtration media shall be used to protect each return air grille or opening. The intent of this will be to prevent construction dust and debris from entering any return or supply air ductwork in the facility. All filtration media shall be replaced immediately prior to occupancy.

3.13 MAINTAINING CLEAN DUCTWORK THROUGHOUT CONSTRUCTION

A. Throughout the duration of construction, all ductwork shall be capped or sealed with sheet metal caps, polyethylene film, or other airtight protective to keep dust, dirt, and construction debris out of ducts. Similar means shall be used to seal air-side connections of HVAC equipment to include, but not limited to, air handling units, fans, terminal air boxes, fan coil units, cabinet heaters, blower coils, and the like.

B. When air terminal devices are installed, contractors shall seal all supply, return, and exhaust grilles with polyethylene film or other airtight protective to keep dust, dirt, and construction debris out of ducts.

C. Should HVAC equipment be started during construction, Contractor shall remove airtight protectives and shall install one-inch thick MERV 8 filter media over all return and exhaust grilles to prevent dust, dirt, and construction debris from entering ductwork. Filter media shall cover the entire grille face and shall be secured such that air cannot bypass filter media.

D. Should filter media become laden with dust and dirt, Contractor shall replace filter media with new media to prevent damage to air distribution system and equipment.

E. The following steps shall be taken during testing, adjusting, and balancing of each air system:

1. All construction activities in all spaces served by the air system shall stop.
2. All airtight protectives and temporary filter media shall be removed from all portions of the air system.
3. Testing, adjusting, and balancing work shall not commence until all construction activity is stopped and all airtight protectives and temporary filter media is removed.
4. Once testing, adjusting, and balancing work is complete for the air system, airtight protectives or temporary filter media shall be installed over all ductwork openings and air terminals on the air system prior to resuming construction activities in any spaces served by the air system.

F. The Owner shall agree the building is sufficiently clean prior to the removal of any filtration media and airtight protectives from air terminal devices.

READINESS CERTIFICATION PRIOR TO FINAL JOBSITE OBSERVATION

To prevent the final job observation from occurring too early, we require that the Contractor review the completion status of the project and, by copy of this document, certify that the job is indeed ready for the final job observation. The following is a typical list of items that represent the degree of job completeness expected prior to your requesting a final job observation.

1. Penetrations fire sealed and labeled in accordance with specifications.
2. All air handling units operating and balanced.
3. All fans shall be operating and balanced.
4. All pumps,  and chillers operating and balanced.
5. All miscellaneous mechanical systems (unit heaters, fan coil units, cabinet heaters, etc.) operating.
6. All temperature control systems operating, programmed and calibrated.
7. Pipe insulation complete, pipes labeled and valves tagged.
8. Fire damper and fire/smoke damper access doors labeled in accordance with specifications.

Accepted by:

Prime Contractor _____

By _____ Date _____

Upon Contractor certification that the project is complete and ready for a final job observation, we require the Contractor to sign this agreement and return it to the Architect/Engineer so that the final observation can be scheduled.

It is understood that if the Architect/Engineer finds the job not ready for the final observation and that additional trips and observations are required to bring the project to completion, the costs incurred by the Architect/Engineers for additional time and expenses will be deducted from the Contractor's contract retainage prior to final payment at the completion of the job.

END OF SECTION 23 05 00

SECTION 23 05 05 - HVAC DEMOLITION FOR REMODELING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Mechanical demolition.

B. Cutting and Patching.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Materials and equipment shall be as specified in individual Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. THE DRAWINGS ARE INTENDED TO INDICATE THE GENERAL SCOPE OF WORK AND DO NOT SHOW EVERY PIPE, DUCT, OR PIECE OF EQUIPMENT THAT MUST BE REMOVED. THE CONTRACTOR SHALL VISIT THE SITE AND VERIFY CONDITIONS PRIOR TO SUBMITTING A BID.

B. Where walls, ceilings, etc., are shown as being removed on general drawings, the Contractor shall remove all mechanical equipment, devices, fixtures, piping, ducts, systems, etc., from the removed area.

C. Where ceilings, walls, partitions, etc., are temporarily removed and replaced by others, This Contractor shall remove, store, and replace equipment, devices, fixtures, pipes, ducts, systems, etc.

D. Verify that abandoned utilities serve only abandoned equipment or facilities. Extend services to facilities or equipment that shall remain in operation following demolition.

E. Coordinate work with all other Contractors and the Owner. Schedule removal of equipment to avoid conflicts.

F. This Contractor shall verify all existing equipment sizes and capacities where equipment is scheduled to be replaced or modified, prior to ordering new equipment.

G. Bid submittal shall mean the Contractor has visited the project site and verified existing conditions and scope of work.

3.2 PREPARATION

A. Disconnect mechanical systems in walls, floors, and ceilings scheduled for removal.

B. Provide temporary connections to maintain existing systems in service during construction. When work must be performed on operating equipment, use personnel experienced in such operations.

C. Existing Heating System: Maintain existing system in service until new system is complete and ready for service. Drain system only to make switchovers and connections. Obtain permission from the Owner at least 48 hours before partially or completely draining system. Minimize outage duration.

3.3 DEMOLITION AND EXTENSION OF EXISTING MECHANICAL WORK

A. Demolish and extend existing mechanical work under provisions of Division 2 and this Section.

B. Remove, relocate, and extend existing installations to accommodate new construction.

C. Remove abandoned ducts and piping to source of supply and/or main lines.

D. Remove exposed abandoned pipes and ducts, including abandoned pipes and ducts above accessible ceilings. Where piping or ducts are located above ceilings not being removed, cap both ends where accessible. Cut ducts flush with walls and floors, cap duct that remains, and patch surfaces. Cut pipes above ceilings, below floors and behind walls. Cap remaining lines. Repair building construction to match original. Remove all clamps, hangers, supports, etc. associated with pipe and duct removal.

E. Disconnect and remove mechanical devices and equipment serving equipment that has been removed.

F. Repair adjacent construction and finishes damaged during demolition and extension work.

G. Maintain access to existing mechanical installations which remain. Modify installation or provide access panels as appropriate.

H. Remove unused sections of supply and return air ductwork back to mains. Patch opening with sheet metal and seal airtight. Patch existing insulation to match existing. Where existing ductwork is to be capped and reused, locate the end cap within 6" of the last branch. End caps shall be 3" pressure class and seal class "A".

I. Extend existing installations using materials and methods compatible with existing installations, or as specified.

3.4 CUTTING AND PATCHING

A. This Contractor is responsible for all penetrations of existing construction required to complete the work of this project. Refer to Section 23 05 29 for additional requirements.

B. Penetrations in existing construction should be reviewed carefully prior to proceeding with any work.

C. Penetrations shall be neat and clean with smooth and/or finished edges. Core drill where possible for clean opening.

D. Repair existing construction as required after penetration is complete to restore to original condition. Use similar materials and match adjacent construction unless otherwise noted or agreed to by the Architect/Engineer prior to start of work.

E. This Contractor is responsible for all costs incurred in repair, relocations, or replacement of any cables, conduits, or other services if damaged without proper investigation.

3.5 CLEANING AND REPAIR

A. Clean and repair existing materials and equipment which remain or are to be reused.

B. Clean all systems adjacent to project which are affected by the dust and debris caused by this construction.

C. MECHANICAL ITEMS REMOVED AND NOT RELOCATED REMAIN THE PROPERTY OF THE OWNER. CONTRACTOR SHALL PLACE ITEMS RETAINED BY THE OWNER IN A LOCATION COORDINATED WITH THE OWNER. THE CONTRACTOR SHALL DISPOSE OF MATERIAL THE OWNER DOES NOT WANT TO REUSE OR RETAIN FOR MAINTENANCE PURPOSES.

3.6 SPECIAL REQUIREMENTS

A. Review locations of all new penetrations in existing floor slabs or walls. Determine construction type and review for possible interferences. Bring all concerns to the attention of the Architect/Engineer before proceeding.

END OF SECTION 23 05 05

SECTION 23 05 13 - MOTORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Single Phase and Three Phase Electric Motors.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00. Include nominal efficiency and power factor for all premium efficiency motors. Efficiencies must meet or exceed the nominal energy efficiency levels presented below.

B. Submit shop drawings for all three phase motors.

C. Submit motor data with equipment when motor is installed by the manufacturer at the factory.

D. Submit shaft grounding device for all motors as required.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof coverings. For extended outdoor storage, follow manufacturer's recommendations for equipment and motor.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data including assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in the manufacture of commercial and industrial motors and accessories, with a minimum of three years documented manufacturing experience.

PART 2 - PRODUCTS

2.1 MOTORS - GENERAL CONSTRUCTION AND REQUIREMENTS

A. Refer to the drawings for required electrical characteristics. Voltage is generally specified and scheduled as distribution voltage. Motor submittals may be based on utilization voltage if it corresponds to the correct distribution voltage.

| Distribution/Nominal Voltage | Utilization Voltage |
|---|---|
| 120 | 115 |
| 208 | 200 |
| 240 | 230 |

| | |
|---|---|
| 277 | 265 |
| 480 | 460 |

B. Design motors for continuous operation in 40°C environment, and for temperature rise in accordance with ANSI/NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.

C. Visible Nameplate: Indicating horsepower, voltage, phase, hertz, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, insulation class.

D. Electrical Connection: Boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide conduit connection in end frame.

E. Unless otherwise indicated, motors 3/4 HP and smaller shall be single phase, 60 hertz, open drip-proof or totally enclosed fan-cooled type.

F. Unless otherwise indicated, motors 1 HP and larger shall be three phase, 60 hertz, squirrel cage type, NEMA Design Code B (low current in-rush, normal starting torque), open drip-proof or totally enclosed fan-cooled type.

G. Each contractor shall set all motors furnished by the contractor.

H. All motors shall have a minimum service factor of 1.15.

I. All motors shall have ball or roller bearings with a minimum L-10 fatigue life of 150,000 hours in direct-coupled applications and 50,000 hours for belted applications. Belted rating shall be based on radial loads and pulley sizes called out in NEMA MG1-14.43.

J. Bearings shall be sealed type for 10 HP and smaller motors. Bearings shall be regreasable type for larger motors.

K. Aluminum end housings are not permitted on motors 15 HP or larger.

L. Motor Driven Equipment:

1. No equipment shall be selected or operate above 90% of its motor nameplate rating. Motor size may not be increased to compensate for equipment with efficiency lower than that specified.
2. If a larger motor than specified is required on equipment, the contractor supplying the equipment is responsible for all additional costs due to larger starters, wiring, etc.

M. Provide all belted motors with a means of moving and securing the motor to tighten belts. Motors over 2 HP shall have screw type tension adjustment. Motors over 40 HP shall have dual screw adjusters. Slide bases shall conform to NEMA standards.

N. Motors for fans and pumps 1/12 HP or greater and less than 1 HP shall be electronically-commutated motors or shall have a minimum motor efficiency of 70% when rated in accordance with DOE 10 CFR 431. These motors shall also have the means to adjust motor speed for either balancing or remote control. Belt-driven fans may use sheave adjustments for airflow balancing in lieu of varying motor speed.

2.2 ELECTRICALLY COMMUTATED MOTORS (ECM)

A. Motor shall be variable speed, constant torque, brushless DC motor for direct-drive applications. Electronics shall be encapsulated for moisture protection and shall integral surge protection. Motor shall be pre-wired for specific voltage and phase.

B. Motor frame shall be NEMA 48; UL recognized components shall be provided for the motor construction.

C. All EC motors shall be a minimum of 85% efficient at all speeds.

D. Motors shall be permanently lubricated; utilize ball bearings to match with the connected driven equipment.

E. Provide motor with on-board motor control module. Motor speed shall be limited to provide electronic over current protection. Starter shall provide soft start to reduce inrush current and shall be controllable from 20% to 100% of full rated speed.

F. Operational mode shall be as scheduled and shall be one of the following:

1. Constant Flow
2. Constant Temperature
3. Constant Pressure

2.3 PREMIUM EFFICIENCY MOTORS (INCLUDING MOST 3-PHASE GENERAL PURPOSE MOTORS)

A. All motors, unless exempted by EPAct legislation that became federal law on December 19, 2010, shall comply with the efficiencies listed in that standard, which are reprinted below. These match the 2010 NEMA premium efficiency ratings. All ratings listed are nominal full load efficiencies, verified in accordance with IEEE Standard 112, Test Method B. Average expected (not guaranteed minimum) power factors shall also be at least the following:

| | Full-Load Efficiencies % | | | | | |
|---|---|---|---|---|---|---|
| | Open Drip-Proof | | | Totally Enclosed Fan Cooled | | |
| HP | 1200 rpm | 1800 rpm | 3600 rpm | 1200 rpm | 1800 rpm | 3600 rpm |
| 1.0 | 82.5 | 85.5 | 77.0 | 82.5 | 85.5 | 77.0 |
| 1.5 | 86.5 | 86.5 | 84.0 | 87.5 | 86.5 | 84.0 |
| 2.0 | 87.5 | 86.5 | 85.5 | 88.5 | 86.5 | 85.5 |
| 3.0 | 88.5 | 89.5 | 85.5 | 89.5 | 89.5 | 86.5 |
| 5.0 | 89.5 | 89.5 | 86.5 | 89.5 | 89.5 | 88.5 |
| 7.5 | 90.2 | 91.0 | 88.5 | 91.0 | 91.7 | 89.5 |
| 10.0 | 91.7 | 91.7 | 89.5 | 91.0 | 91.7 | 90.2 |
| 15.0 | 91.7 | 93.0 | 90.2 | 91.7 | 92.4 | 91.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 20.0 | 92.4 | 93.0 | 91.0 | 91.7 | 93.0 | 91.0 |
| 25.0 | 93.0 | 93.6 | 91.7 | 93.0 | 93.6 | 91.7 |
| 30.0 | 93.6 | 94.1 | 91.7 | 93.0 | 93.6 | 91.7 |

B. Motor nameplate shall be noted with the above ratings.

2.4 MOTORS ON VARIABLE FREQUENCY DRIVES

A. All motors driven by VFDs shall be premium efficiency type.

B. Motors shall be designed for use with VFDs in variable torque applications with 1.15 service factor. Motors shall not be equipped with auxiliary blowers.

C. Motors driven by VFDs shall have Class F or H insulation and be designated by the motor manufacturer to be suitable for inverter duty service in accordance with NEMA MG 1 Section IV, "Performance Standards Applying to All Machines," Part 31 "Definite-Purpose Inverter-Fed Polyphase Motors.

D. All 480-volt motors controlled by VFDs shall be equipped with an alternate discharge path, such as a shaft grounding ring or grounding brush, to divert adverse shaft currents from the motor bearings on the drive end of the motor shaft. Motor shafts 2"50 mm and larger require shaft grounding on the drive end and the non-drive end. This Contractor shall ensure (via field observation and measurement) that the shaft is effectively grounded upon startup.

1. Providing grounding rings internal to the motor housing is an acceptable solution, provided the motor is affixed with a label clearly indicating the presence of a grounding assembly. The grounding ring shall be listed for 40,000 hours of motor service and shall be accessible via the drive endplate.
2. The following critical motors shall also be equipped with shaft grounding kits:

    a. Chilled water pumps
    b. Heating water pumps
    c. DOAS/RTU

PART 3 - EXECUTION

3.1 INSTALLATION

A. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Contractor is responsible for providing this guarding if it is not provided with the equipment supplied.

B. For flexible coupled drive motors, mount coupling to the shafts in accordance with the coupling manufacturer's recommendations. Align shafts to manufacturer's requirements or within 0.002 inch per inch diameter of coupling hub.

C. For belt drive motors, mount sheaves on the appropriate shafts per manufacturer's instructions. Use a straight edge to check alignment of the sheaves. Reposition sheaves as necessary so the straight edge contacts both sheave faces squarely. After sheaves are aligned, loosen the adjustable motor base so the belt(s) can be added, and tighten the base so the belt tension is in accordance with the drive manufacturer's recommendations. Frequently check belt tension and adjust if necessary during the first day of operation and again after 80 hours of operation.

END OF SECTION 23 05 13

SECTION 23 05 29 - HVAC SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Hangers, Supports, and Associated Anchors.

B. Equipment Bases and Supports.

C. Sleeves and Seals.

D. Flashing and Sealing of Equipment and Pipe Stacks.

E. Cutting of Openings.

F. Escutcheon Plates and Trim.

1.2 WORK FURNISHED BUT INSTALLED UNDER OTHER SECTIONS

A. Furnish sleeves and hanger inserts to General Contractor for placement into formwork.

PART 2 - PRODUCTS

2.1 HANGER RODS

A. Hanger rods for single rod hangers shall conform to the following:

| | Hanger Rod Diameter | |
|---|---|---|
| Pipe Size | Column #1 | Column #2 |
| 2" and smaller | 3/8" | 3/8" |
| 2-1/2" through 3-5/8" | 1/2" | 1/2" |
| 4" and 5" | 5/8" | 1/2" |
| 6" | 3/4" | 5/8" |

Column #1: Steel pipe.
Column #2: Copper pipe.

B. Rods for double rod hangers may be reduced one size. Minimum rod diameter is 3/8 inches.

C. Hanger rods and accessories used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.

D. All hanger rods, nuts, washers, clevises, etc., in damp areas shall have ASTM A123 hot-dip galvanized finish applied after fabrication. This applies to the following areas:

1. Tunnels

## 2.2 PIPE AND STRUCTURAL SUPPORTS

A. General:

1. Pipe hangers, clamps, and supports shall conform to Manufacturers Standardization Society MSS SP-58, 69, 89, and 127 (where applicable).
2. On all insulated piping, provide at each support an insert of same thickness and contour as adjoining insulation, between the pipe and insulation jacket, to prevent insulation from sagging and crushing. Refer to insulation specifications for materials and additional information.

B. Vertical Supports:

1. Support and laterally brace vertical pipes at every floor level in multi-story structures, unless otherwise noted by applicable codes, but never at intervals over 15 feet. Support vertical pipes with riser clamps installed below hubs, couplings, or lugs. Provide sufficient flexibility to accommodate expansion and contraction to avoid compromising fire barrier penetrations or stressing piping at fixed takeoff locations.

    a. Products:

        1) Cooper/B-Line Fig B3373 Series
        2) Erico 510 Series
        3) Nibco/Tolco Fig. 82

2. Cold Pipe: Place restrained neoprene mounts beneath vertical pipe riser clamps to prevent sweating of cold pipes. Select neoprene mounts based on the weight of the pipe to be supported. Insulate over mounts.

    a. Products:

        1) Mason RBA, RCA or RDA
        2) Mason BR

3. Cold Pipe Alternative: Insulated pipe riser clamp with no thermal bridging between clamp and pipe; water repellant calcium silicate insulation material adhered inside the clamp; ASTM A653 galvanized steel clamp.

    a. Products:

        1) Pipeshields E100

4. Wall supports shall be used where vertical height of structure exceeds minimum spacing requirements. Install wall supports at same spacing as hangers or strut supports along vertical length of pipe runs. Wall supports shall be coordinated with the Structural Engineer.

C. Hangers and Clamps:

1. Oversize all hangers, clamps, and supports on insulated piping to allow insulation and jacket to pass through unbroken. This applies to both hot and cold pipes.

2. Hangers in direct contact with bare copper pipe shall include plastic pipe insert similar to Unistrut Cush-A-Clamp, Hydra-Zorb, Erico Cushion Clamp or Cooper Vibra-Clamp within their temperature limits of -65°F to +275°F.
3. On all insulated piping, provide a semi-cylindrical metallic shield and vapor barrier jacket.
4. Ferrous hot piping 4 inches and larger shall have steel saddles tack welded to the pipe at each support with a depth not less than specified for the insulation. Factory fabricated inserts may be used.

    a. Products:

        1) Anvil Fig. 160, 161, 162, 163, 164, 165
        2) Cooper/B-Line Fig. 3160, 3161, 3162, 3163, 3164, 3165
        3) Erico Model 630, 631, 632, 633, 634, 635
        4) Nibco/Tolco Fig. 260-1, 261-1 1/2, 262-2, 263-2 1/2, 264-3, 265-4

5. Unless otherwise indicated, hangers shall be as follows:

    a. Clevis Type: Service: Bare Metal Pipe, Insulated Cold Pipe, Insulated Hot Pipe - 3 inches and Smaller:

        1) Products: Bare Steel, Plastic or Insulated Pipe:

            a) Anvil Fig. 260
            b) Cooper/B-Line Fig. 3100
            c) Erico Model 400
            d) Nibco/Tolco Fig. 1

        2) Products: Bare Copper Pipe:

            a) Cooper/B-Line Fig. B3100C
            b) Nibco/Tolco Fig. 81PVC

    b. Roller Type: Service: Insulated Hot Pipe - 4 inches and Larger:

        1) Products: 4" through 6":

            a) Anvil Fig. 181, 271
            b) Cooper/B-Line Fig. 3110, 3117
            c) Erico Model 610
            d) Nibco/Tolco Fig. 324, 327

    c. Adjustable Swivel Ring Type: Service: Bare Metal Pipe - 4 inches and Smaller:

        1) Products: Bare Steel Pipe:

            a) Anvil Fig. 69
            b) Cooper/B-Line Fig. B3170NF
            c) Erico Model FCN
            d) Nibco/Tolco Fig. 200.

2) Products: Bare Copper Pipe:

a) Cooper/B-Line Fig. B3170CTC
b) Erico 102A0 Series
c) Nibco/Tolco Fig. 203

6. Support may be fabricated from U-channel strut or similar shapes. Piping less than 4" in diameter shall be secured to strut with clamps of proper design and capacity as required to maintain spacing and alignment. Strut shall be independently supported from hanger drops or building structure. Size and support shall be per manufacturer's installation requirements for structural support of piping. Clamps shall not interrupt piping insulation.

a. Strut used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.
b. Strut used in damp areas listed in hanger rods shall have ASTM A123 hot-dip galvanized finish applied after fabrication.

7. Unless otherwise indicated, pipe supports for use with struts shall be as follows:

a. Clamp Type: Service: Bare Metal Pipe, Rigid Plastic Pipe, Insulated Cold Pipe, Insulated Hot Pipe - 3 inches and smaller:

1) Clamps in direct contact with copper pipe shall include plastic pipe insert similar to Unistrut Cush-A-Clamp, Hydra-Zorb, Erico Cushion Clamp or Cooper Vibra-Clamp.
2) Pipes subject to expansion and contraction shall have clamps oversized to allow limited pipe movement.
3) Products: Bare Steel, Plastic or Insulated Pipe:

a) Unistrut Fig. P1100 or P2500
b) Cooper/B-Line Fig. B2000 or B2400
c) Nibco/Tolco Fig. A-14 or 2STR

4) Products: Bare Copper Pipe:

a) Cooper/B-Line Fig. BVT

b. Roller Type: Service: Insulated Hot Pipe - 4 inches and larger:

1) Products: 4" through 6":

a) Unistrut Fig. P2474
b) Cooper/B-Line Fig. B218
c) Nibco/Tolco Fig. ROL-12

D. Upper (Structural) Attachments:

1. Unless otherwise shown, upper attachments for hanger rods or support struts shall be as follows:

a. Steel Structure Clamps: C-Type Wide Flange Beam Clamps (for use on top and/or bottom of wide flanges. Not permitted for use with bar-joists.):

1) Products:

a) Anvil Fig. 92
b) Cooper/B-Line Fig. B3033/B3034
c) Erico Model 300
d) Nibco/Tolco 68

b. Scissor Type Beam Clamps (for use with bar-joists and wide flange):

1) Products:

a) Anvil Fig. 228, 292
b) Cooper/B-Line Fig. B3054
c) Erico Model 360
d) Nibco/Tolco Fig. 329

c. Concentrically Loaded Open Web Joist Hangers (for use with bar joists):

1) Products:

a) MCL. M1, M2 or M3

2.3 FOUNDATIONS, BASES, AND SUPPORTS

A. Basic Requirements:

1. Furnish and install foundations, bases, and supports (not specifically indicated on the Drawings or in the Specifications of either the General Construction or Mechanical work as provided by another Contractor) for mechanical equipment.
2. All concrete foundations, bases and supports, shall be reinforced. All steel bases and supports shall receive a prime coat of zinc chromate or red metal primer. After completion of work, give steel supports a final coat of gray enamel.

B. Concrete Bases (Housekeeping Pads):

1. Refer to Section 23 05 50 for additional requirements for concrete bases in seismic applications.
2. Unless shown otherwise on the drawings, concrete bases shall be nominal 4 inches thick and shall extend 3 inches on all sides of the equipment (6 inches larger than factory base).
3. Where a base is less than 12 inches from a wall, extend the base to the wall to prevent a "dirt-trap".
4. Concrete materials and workmanship required for the Contractor's work shall be provided by the Contractor. Materials and workmanship shall conform to the applicable standards of the Portland Cement Association. Reinforce with 6"x6", W1.4-W1.4 welded wire fabric. Concrete shall withstand 3,000 pounds compression per square inch at 28 days (be 20 MPa strength).
5. Equipment requiring bases is as follows:

a. Air Handling Unit
b. Expansion Tank
c. Heat Exchanger
d. Pump

C. Supports:

1. Provide sufficient clips, inserts, hangers, racks, rods, and auxiliary steel to securely support all suspended material, equipment and conduit without sag.
2. Hang heavy equipment from concrete floors or ceilings with Architect/Engineer-approved concrete inserts, furnished and installed by the Contractor whose work requires them, except where indicated otherwise.

D. Grout:

1. Grout shall be non-shrinking premixed (Master Builders Company "Embecco"), unless otherwise indicated on the drawings or approved by the Architect/Engineer.
2. Use Mix No. 1 for clearances of 1" or less, and Mix No. 2 for all larger clearances.
3. Grout under equipment bases, around pipes, at pipe sleeves, etc., and where shown on the drawings.

2.4 OPENINGS IN FLOORS, WALLS AND CEILINGS

A. Exact locations of all openings for the installation of materials shall be determined by the Contractor and given to the General Contractor for installation or construction as the structure is built.

B. Coordinate all openings with other Contractors.

C. Hire the proper tradesman and furnish all labor, material and equipment to cut openings in or through existing structures, or openings in new structures that were not installed, or additional openings. Repair all spalling and damage to the satisfaction of the Architect/Engineer. Make saw cuts before breaking out concrete to ensure even and uniform opening edges.

D. Said cutting shall be at the complete expense of each Contractor. Failure to coordinate openings with other Contractors shall not exempt the Contractor from providing openings at Contractor's expense.

E. Do not cut structural members without written approval of the Architect or Structural Engineer.

2.5 ROOF PENETRATIONS

A. Roof Curb Enclosure: Provide weatherproof roof curb and enclosure for pipe and duct penetrations. Refer to drawings for details.

B. Conical Pipe Boot: Seal pipes with surface temperature below 150°F penetrating single-ply roofs with conical stepped, UV-resistant silicone, EPDM or neoprene pipe flashings and stainless steel clamps equal to Portals Plus Pipe Boots or Pipetite. Color: White shall match roofing material.

C. Break insulation only at the clamp for pipes between 60°F and 150°F. Seal outdoor insulation edges watertight.

2.6 SLEEVES AND LINTELS

A. Each Contractor shall provide sleeves and lintels for all duct and pipe openings required for the Contractor's work in masonry walls and floors, unless specifically shown as being by others.

B. Fabricate all sleeves from standard weight black steel pipe or as indicated on the drawings. Provide continuous sleeve. Cut or split sleeves are not acceptable.

C. Fabricate all lintels for masonry walls from structural steel shapes or as indicated on the drawings. Have all lintels approved by the Architect or Structural Engineer.

D. Sleeves through the floors on exposed risers shall be flush with the ceiling, with planed squared ends extending 1" above the floor in unfinished areas, and flush with the floor in finished areas, to accept spring closing floor plates.

E. Sleeves shall not penetrate structural members or masonry walls without approval from the Structural Engineer. Sleeves shall then comply with the Architect/Engineer's design.

F. Install all sleeves concentric with pipes. Secure sleeves in concrete to wood forms. This Contractor is responsible for sleeves dislodged or moved when pouring concrete.

G. Where pipes rise through concrete floors that are on earthen grade, provide 3/4" resilient expansion joint material (e.g., foam, rubber, asphalt-coated fiber, bituminous-impregnated felt, or cork) wrapped around the pipe, the full depth of concrete, at the point of penetration. Secure to prevent shifting during concrete placement and finishing.

H. Size sleeves large enough to allow expansion and contraction movement. Provide continuous insulation wrapping.

2.7 ESCUTCHEON PLATES AND TRIM

A. Fit escutcheons to all insulated or uninsulated exposed pipes passing through walls, floors, or ceilings of finished rooms.

B. Escutcheons shall be heavy gauge, cold rolled steel, copper coated under a chromium plated finish, heavy spring clip, rigid hinge and latch.

C. Install galvanized steel (unless otherwise indicated) trim strip to cover vacant space and raw construction edges of all rectangular openings in finished rooms. This includes pipe openings.

2.8 PIPE PENETRATIONS

A. Seal all pipe penetrations. Seal non-rated walls and floor penetrations with grout or caulk. Backing material may be used.

B. Seal fire rated wall and floor penetrations with fire seal system as specified.

2.9 PIPE ANCHORS

A. Provide all items needed to allow adequate expansion and contraction of all piping. All piping shall be supported, guided, aligned, and anchored as required.

B. Repair all piping leaks and associated damage. Pipes shall not rub on any part of the building.

2.10 FINISH

A. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

PART 3 - EXECUTION

3.1 HVAC SUPPORTS AND ANCHORS

A. General Installation Requirements:

1. Install all items per manufacturer's instructions.
2. Coordinate the location and method of support of piping systems with all installations under other Divisions and Sections of the Specifications.
3. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
4. Supports shall extend directly to building structure. Do not support piping from duct hangers unless coordinated with sheet metal contractor prior to installation. Do not allow lighting or ceiling supports to be hung from piping supports.

B. Supports Requirements:

1. Furnish, install and prime all auxiliary structural steel for support of piping systems that are not shown on the Drawings as being by others.
2. Install hangers and supports complete with lock nuts, clamps, rods, bolts, couplings, swivels, inserts and required accessories.
3. Hangers for horizontal piping shall have adequate means of vertical adjustment for alignment.

C. Pipe Requirements:

1. Support all piping and equipment, including valves, strainers, traps and other specialties and accessories to avoid objectionable or excessive stress, deflection, swaying, sagging or vibration in the piping or building structure during erection, cleaning, testing and normal operation of the systems.
2. Do not, however, restrain piping to cause it to snake or buckle between supports or to prevent proper movement due to expansion and contraction.
3. Support piping at equipment and valves so they can be disconnected and removed without further supporting the piping.
4. Piping shall not introduce strains or distortion to connected equipment.
5. Parallel horizontal pipes may be supported on trapeze hangers made of structural shapes and hanger rods; otherwise, pipes shall be supported with individual hangers.
6. Trapeze hangers may be used where ducts interfere with normal pipe hanging.

7. Provide additional supports where pipe changes direction, adjacent to flanged valves and strainers, at equipment connections and heavy fittings.
8. Provide at least one hanger adjacent to each joint in grooved end steel pipe with mechanical couplings.

D. Provided the installation complies with all loading requirements of truss and joist manufacturers, the following practices are acceptable:

1. Loads of 100 lbs. or less may be attached anywhere along the top or bottom chords of trusses or joists with a minimum 3' spacing between loads.
2. Loads greater than 100 lbs. must be hung concentrically and may be hung from top or bottom chord, provided one of the following conditions is met:

    a. The hanger is attached within 6" from a web/chord joint.
    b. Additional L2x2x1/4 web reinforcement is installed per manufacturer's requirements.

3. It is prohibited to cantilever a load using an angle or other structural component that is attached to a truss or joist in such a fashion that a torsional force is applied to that structural member.
4. If conditions cannot be met, coordinate installation with truss or joist manufacturer and contact Architect/Engineer.

E. After piping and insulation installation are complete, cut hanger rods back at trapeze supports so they do not extend more than 3/4" below bottom face of lowest fastener and blunt any sharp edges.

F. Do not exceed 25 lbs. per hanger and a minimum spacing of 2'-0" on center when attaching to metal roof decking (limitation not required with concrete on metal deck). This 25 lbs. load and 2'-0" spacing include adjacent electrical and architectural items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

G. Do not exceed the manufacturer's recommended maximum load for any hanger or support.

H. Steel/Concrete Structure: Spacing of hangers shall not exceed the compressive strength of the insulation inserts, and in no case shall exceed the following:

1. Steel and Fiberglass (Std. Weight or Heavier - Liquid Service):

    a. Maximum Spacing:

        1) 1-1/4" & under: 7'-0"
        2) 1-1/2": 9'-0"
        3) 2": 10'-0"
        4) 2-1/2": 11'-0"
        5) 3": 12'-0"
        6) 4" & larger: 12'-0"

2. Steel (Std. Weight or Heavier - Vapor Service):

a. Maximum Spacing:

1) 1-1/4" and under: 9'-0"
2) 1-1/2": 12'-0"
3) 2" & larger: 12'-0"

3. Hard Drawn Copper & Brass (Liquid Service):

a. Maximum Spacing:

1) 3/4" and under: 5'-0"
2) 1": 6'-0"
3) 1-1/4": 7'-0"
4) 1-1/2" 8'-0"
5) 2": 8'-0"
6) 2-1/2": 9'-0"
7) 3": 10'-0"
8) 4": 12'-0"
9) 6": 12'-0"

I. Installation of hangers shall conform to MSS SP-58, 69, and 89.

END OF SECTION 23 05 29

SECTION 23 05 30 - ROOF SUPPORT AND WIND BRACING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Wind Restraint of Rooftop Equipment

B. Rooftop Duct Support

C. Rooftop Pipe Support

D. Rooftop Equipment Support

1.2 QUALITY ASSURANCE

A. General:

1. The Contractor shall retain a specialty consultant or equipment manufacturer to develop a wind restraint and support system and perform wind restraint calculations in accordance with these specifications, state, and local codes.
2. These requirements are beyond those listed in Section 23 05 50 of these specifications. Where a conflict arises between the wind restraint of this section and any other section, the Architect/Engineer shall be immediately notified for direction to proceed.

B. Manufacturer:

1. System Supports/Restraints: Company specializing in the manufacture of products specified in this section.
2. Equipment: Each company providing equipment that must meet wind restraint requirements shall provide certification included in project submittals that the equipment supplied for the project meets or exceeds the wind restraint of the project.

C. Installer: Installed by Contractor.

1.3 REFERENCES

A. International Building Code 2015

B. Technical Manual 5-809-10, NAVFAC P-355, Air Force Manual 88-3, Chapter 13

C. Illinois Capital Development Board, Design and Construction Manual, March 2009

D. ASCE 7-16, Chapter 29

1.4 SUBMITTALS

A. Submit under provisions of Section 23 05 00.

B. Shop Drawings:

1. Calculations, restraint selections, and installation details shall be designed and sealed by a Structural Engineer licensed in the state where the project is located and experienced in wind restraint design and installation.
2. Coordination Drawings: Plans and sections drawn to scale, coordinating wind restraint bracing of mechanical components with other systems and equipment in the vicinity, including other wind restraint restraints.
3. Manufacturer's Certifications: Structural Engineer licensed in the state where the project is located shall review and approve manufacturer's certifications of compliance.
4. System Supports/Restraints - Submit for each condition requiring wind restraint bracing:

    a. Calculations for each wind restraint brace and detail used on the project.
    b. Plan drawings showing locations and types of wind restraint braces on contractor fabrication/installation drawings.
    c. Cross-reference between details and plan drawings to indicate exactly which brace is being installed at each location. Details provided are to clearly indicate attachments to structure, correctly representing the fastening requirements of bracing.
    d. Clear indication of brace design forces and maximum potential component forces at attachment points to building structure for confirmation of acceptability by the Structural Engineer of Record.

5. Equipment - Submit for each piece of equipment supplied:

    a. Certification that the equipment supplied for the project meets or exceeds the wind restraint requirements specified.
    b. Specific details of wind restraint design features of equipment and maximum wind restraint loads imparted to the structural support.
    c. Engineering calculations and details for equipment anchorage and support structure.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver, store, protect and handle products to site. Accept material on site in factory containers and packing. Inspect for damage. Protect from damage and contamination by maintaining factory packaging until installation. Follow manufacturer's instructions for storage.

1.6 DESIGN REQUIREMENTS

A. This project is subject to the wind loading requirements of the International Building Code 2015 edition.

B. The total height of the structure and the height of the system to be restrained within the structure shall be determined in coordination with architectural plans and the General Contractor.

1.7 COORDINATION

A. Coordinate layout and installation of anchoring with building structural systems and architectural features, and with mechanical, fire-protection, electrical and other building features in the vicinity.

1.8 WARRANTY

A. Provide one-year warranty on parts and labor for manufacturer defects and installation workmanship.

PART 2 - PRODUCTS

2.1 SUPPLIERS

A. Miro Industries

2.2 DESIGN CRITERIA

A. The following design criteria applies to all equipment noted below.

B. General Information:

1. Adopted Building Code:IBC- IBC 2015 and Building Code of Rockford, State of Illinois
2. Building Occupancy Risk Category: III

C. Wind Design Criteria:

1. Mean Roof Height: Insert Varies
2. Basic Wind Speed: 120 MPH @ 3-second gust
3. Exposure Category: B

2.3 ROOF DUCT SUPPORTS

A. Roof duct support manufacturer shall provide ASCE-7 code-compliant sealed submittal to support and restrain rooftop duct system for uplift and lateral loading.

B. Refer to drawings for duct size, layout, structural framing, roofing material, and wind and seismic loading information.

C. Provide adjustable pre-fabricated roof duct supports for all duct installed on the roof. Supports include a combination of non-penetrating pillow block duct supports and stanchioned supports anchored to the roof structure.

D. Supports shall be constructed from hot dipped galvanized steel minimum 12-gauge channel or tube steel. Manufacturer shall determine final design.

E. Pillow block base shall be UV resistant polycarbonate rounded to prevent damage to the roof, and drainage holes shall prevent ponding of water in the support.

F. Acceptable Manufacturer:

1. Miro Industries DS and Stanchioned DS

2.4 ROOF PIPING SUPPORTS

A. Non-Penetrating Pillow Block Supports:

1. Provide pre-fabricated non-penetrating pillow block roof pipe supports for all piping installed on the roof.
2. Pillow block base shall be UV resistant polycarbonate rounded to prevent damage to the roof, and drainage holes shall prevent ponding of water in the support.
3. Acceptable Products:

a. Anvil International HBS-Base Series
b. Cooper B-Line Dura-Blok
c. Erico Caddy Pyramid 50, 150, 300, or 600 (to match load)
d. Miro Industries 1.5, 3-R, 4-R or 5-R (to match pipe)

B. Premanufactured Anchored Roof Pipe Supports:

1. Roof duct support manufacturer shall provide ASCE-7 code-compliant sealed submittal to support and restrain rooftop piping system for uplift and lateral loading.
2. Refer to drawings for pipe size, layout, structural framing, roofing material, and wind and seismic loading information.
3. Provide adjustable pre-fabricated pipe supports for all pipe installed on the roof. Supports include a combination of non-penetrating pillow block pipe supports and stanchioned supports anchored to the roof structure.

a. Supports shall be constructed from hot dipped galvanized steel minimum 12-gauge channel or tube steel. Manufacturer shall determine final design.

4. Pillow block base shall be UV resistant polycarbonate rounded to prevent damage to the roof, and drainage holes shall prevent ponding of water in the support.
5. Acceptable Manufacturer:

a. Miro Industries DS and Stanchioned DS

2.5 ROOF EQUIPMENT SUPPORTS

A. Premanufactured Equipment Roof Support Frames:

1. Roof equipment support manufacturer shall provide ASCE-7 code-compliant sealed submittal to support and restrain rooftop equipment for uplift and lateral loading.
2. Refer to drawings for equipment size, layout, structural framing, roofing material, and wind speed.
3. Provide adjustable prefabricated roof equipment supports for all equipment installed on the roof. Supports include stanchioned supports anchored to the roof structure.
4. Frame: Support frame shall be hot dipped galvanized steel minimum 12 gauge channel or tube steel. Manufacturer shall determine final design.

5. Decking: Support decking shall be minimum 1" thick, non-slip hot dipped galvanized bar grating.
6. Equipment requiring support frames is as follows:

    a. VRF outdoor units

7. Minimum clear height above roof shall be 24 inches .
8. Acceptable Manufacturer:

    a. Miro Industries LD/HD

B. Equipment Roof Curbs and Rails:

1. Equipment requiring curbs or rails with this section is as follows:

    a. Condensing units
    b. VRF outdoor units
    c. Split system outdoor units
    d. Heat recovery ventilators

2. Provide prefabricated curbs or rails as follows:

    a. Roof Mounting Curb: Curb height as shown on drawings, minimum 14 gauge galvanized steel, one-piece construction, insulated, all welded, wood nailer.
    b. 18 gauge galvanized sheet metal, as required for the equipment weight.
    c. Internal reinforcing.
    d. Pressure treated wood nailer.
    e. 18 gauge counter flashing completely covering nailer.
    f. Factory insulated with rigid fiberglass.

3. Refer to drawings for curb and rail heights.
4. Match units to the building roof with either a raised cant to match roof insulation (for built-up roofs) or with no cant (for single-ply roofs).
5. Where legs of equipment rest on rails, provide 1/4" bent plates 18" long.
6. Manufacturers:

    a. Thy
    b. Pate
    c. United
    d. Portals Plus

C. Rooftop Air Handling Units:

1. Standard Curb: Rooftop equipment such as packaged air handling units shall be provided with curbs by the unit manufacturer. Refer to individual equipment sections for curb description.
2. No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration-isolation system specified.
3. This section shall provide anchoring such as Z-clip wind restraint brackets, guy wires, tethers or straps to limit wind disruption.

4. Roof equipment support manufacturer shall provide ASCE-7 code-compliant sealed submittal to support and restrain rooftop equipment for uplift and lateral loading.

D. Exhaust Fans, Roof Hoods, Etc.:

1. Curb provided with equipment. Rooftop equipment such as roof hoods and rooftop exhaust fans shall be provided with curbs by the unit manufacturer. Refer to individual equipment sections for curb description.
2. This section shall provide anchoring such as guy wires, tethers, or straps to limit wind disruption.
3. Roof equipment support manufacturer shall provide ASCE-7 code-compliant sealed submittal to support and restrain rooftop equipment for uplift and lateral loading.

## PART 3 - EXECUTION

### 3.1 GENERAL

A. Install all items per manufacturer's instructions.

B. All wind restraint systems shall be installed in strict accordance with the manufacturer's written instructions and all certified submittal data.

C. Installation of wind restraints shall not cause any change in position of equipment, piping, or ductwork resulting in stresses or misalignment.

D. Prior to installation, bring to the Architect/Engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.

E. Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast-in-place inserts.

F. Cable restraints shall be installed slightly slack to avoid short-circuiting the isolated suspended equipment, ductwork, piping, or conduit. Cable assemblies shall be installed taut on non-isolated systems. Solid braces may be used in place of cables on rigidly attached systems only. Do not install cables over sharp corners.

G. Provide reinforced clevis bolts when required.

H. The vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not acceptable.

I. Piping crossing building seismic or expansion joints, passing from building to building, or supported from different portions of the building shall be installed to allow differential support displacements without damaging the pipe, equipment connections, or support connections. Pipe offsets, loops, anchors, and guides shall be installed as required to provide required motion capability and limit motion of adjacent piping.

J. Positively attach all roof-mounted equipment to roof curbs. Positively attach all roof curbs to building structure.

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

L. Supports shall extend directly to building structure.

M. Furnish, install and prime all auxiliary structural steel for support of piping systems that are not shown on the drawings as being by others.

N. Install hangers and supports complete with lock nuts, clamps, rods, bolts, couplings, swivels, inserts and required accessories.

O. Roof Supports: Install per manufacturer's requirements. Coordinate with Roofing Contractor.

3.2 ROOF PIPING SUPPORTS

A. Roof Supports: Install per manufacturer's requirements. Coordinate with Roofing Contractor.

B. Install roof pipe supports to resist wind movement per manufacturer's recommendations. Method of securing base to roof shall be compatible with roofing materials.

C. Hangers for horizontal piping shall have adequate means of vertical adjustment for alignment.

D. Support all piping and equipment, including valves, strainers, traps and other specialties and accessories, to avoid objectionable or excessive stress, deflection, swaying, sagging or vibration in the piping or building structure during erection, cleaning, testing and normal operation of the systems.

E. Do not, however, restrain piping to cause it to snake or buckle between supports or to prevent proper movement due to expansion and contraction.

F. Support piping at equipment and valves so it can be disconnected and removed without further supporting the piping.

G. Piping shall not introduce strains or distortion to connected equipment.

H. Provide additional supports where pipe changes direction, adjacent to flanged valves and strainers, and at equipment connections and heavy fittings.

I. Provide at least one hanger adjacent to each joint in grooved end steel pipe with mechanical couplings.

J. Spacing: Refer to Supports and Anchors section for pipe spacing requirements.

END OF SECTION 23 05 30

SECTION 23 05 48 - HVAC VIBRATION ISOLATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Bases.

B. Vibration Isolation.

C. Flexible Connectors.

1.2 SUBMITTALS

A. Submit shop drawings per Section 23 05 00 and the Vibration Isolation Submittal Form at the end of this section.

B. Vibration isolation submittals may be included with equipment being isolated, but must comply with this section.

C. Base submittals shall include equipment served, construction, coatings, weights, and dimensions.

D. Isolator submittals shall include:

1. Type of Isolator
2. Load in Pounds per Isolator
3. Recommended Maximum Load for Isolator
4. Spring Constants of Isolators (for Spring Isolators)
5. Load vs. Deflection Curves (for Neoprene Isolators)
6. Specified Deflection
7. Deflection to Solid (at least 150% of calculated deflection)
8. Loaded (Operating) Deflection
9. Free Height
10. Loaded Height
11. Kx/Ky (horizontal to vertical stiffness ratio - for spring isolators)
12. Materials and Coatings
13. Spring Diameters

E. Make separate calculations for each isolator on equipment where the load is not equally distributed.

F. Flexible connector shop drawings shall include overall face-to-face length and all specified properties.

PART 2 - PRODUCTS

2.1 BASIC CONSTRUCTION AND REQUIREMENT

A. Vibration isolators shall have either known undeflected heights or other markings so deflection under load can be verified.

B. All isolators shall operate in the linear portion of their load versus deflection curve. The linear portion of the deflection curve of all spring isolators shall extend 50% beyond the calculated operating deflection (e.g., 3" for 2" calculated deflection). The point of 50% additional deflection shall not exceed the recommended load rating of the isolator.

C. The lateral to vertical stiffness ratio (Kx/Ky) of spring isolators shall be between 0.8 and 2.0.

D. All neoprene shall have UV resistance sufficient for 20 years of outdoor service.

E. All isolators shall be designed or treated for corrosion resistance. Steel bases shall be cleaned of welding slag and primed for interior use, and hot dip galvanized after fabrication for exterior use. All bolts and washers over 3/8" diameter located outdoors shall be hot dip galvanized per ASTM A153. All other bolts, nuts and washers shall be zinc electroplated. All ferrous portions of isolators, other than springs, for exterior use shall be hot dip galvanized after fabrication. Outdoor springs shall be neoprene dipped or hot dip galvanized. All damage to coatings shall be field repaired with two coats of zinc rich coating.

F. Equip all mountings used with structural steel bases with height-saving brackets. Bottoms of the brackets shall be 1-1/2" to 2-1/2" above the floor or housekeeping pad, unless shown otherwise on the drawings. Steel bases shall have at least four points of support.

G. Provide motor slide rails for belt-driven equipment per Section 23 05 13.

H. All isolators, except M1, shall have provision for leveling.

2.2 MOUNTINGS

A. Type M1:

1. 0.75" thick waffled neoprene pad with minimum static deflection of 0.07" at calculated load and 0.11" at maximum load. For loads less than 15 pounds, the deflection at calculated load requirement is waived, but the isolator must have a maximum stiffness of the ratio of 45#/0.35".
2. Units need not be bolted down unless called for or needed to prevent movement. If bolted down, prevent short circuiting with neoprene bushings and washers between bolts and isolators.
3. Manufacturers:

    a. Mason "Super W"
    b. Kinetics "NGS"
    c. Amber/Booth "SPNR"
    d. Vibration Eliminator Co. "400N"

2.3 HANGERS

A. Type H1:

1. Vibration hangers shall consist of a double-deflection neoprene element with a projecting bushing or oversized opening to prevent steel-to-steel contact.
2. Static deflection shall be at least 0.15" at calculated load and 0.35" at maximum rated load.
3. Provide hangers with end connections as required for hanging ductwork or piping.
4. Manufacturers:

    a. Mason "HD"
    b. Kinetics "RH"
    c. Aeroflex "RHD"
    d. Vibration Eliminator Co. "IC/3C/3CTD"
    e. Vibro Acoustics "RH"

B. Type H2:

1. Vibration hangers shall contain a steel spring in a neoprene cup with a grommet to prevent short circuiting the hanger rod.
2. The cup shall have a steel washer to distribute load on the neoprene and prevent its extrusion.
3. Static deflection shall be at least 1.0" (4 mm) at calculated load and 2.0" (9 mm) at maximum rated load.
4. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the grommet and short circuiting the spring.
5. Provide end connections for hanging ductwork or piping.
6. Manufacturers:

    a. Mason "30"
    b. Kinetics "SRH"
    c. Amber/Booth "BSRA"
    d. Aeroflex "RSH"
    e. Vibration Eliminator Co. "SNC"
    f. Vibro Acoustics "SH/SHC"

2.4 BASES

A. Type B2:

1. Steel members welded to height-saving brackets to cradle machines having legs or bases that do not require complete supplementary bases.
2. Members shall be sufficiently rigid to prevent strains in the equipment.
3. Manufacturers:

    a. Mason "ICS"
    b. Kinetics "SFB"
    c. Aeroflex

2.5 FLEXIBLE CONNECTORS (NOISE AND VIBRATION ELIMINATORS)

A. Type FC1:

1. Spherical flexible connectors with multiple plies of nylon tire cord fabric and either EPDM or molded and cured neoprene. Outdoor units shall be EPDM.
2. Steel aircraft cables or threaded steel rods shall be used to prevent excess elongation.
3. All straight through connections shall be made with twin-spheres properly pre-extended as recommended by the manufacturer.
4. Connectors up to 2" size may have threaded ends.
5. Connectors 2-1/2" and over shall have floating steel flanges recessed to lock raised face neoprene flanges.
6. All connectors shall be rated for a minimum working pressure of 150 psi at 200°F.
7. Manufacturer:

a. Metraflex "Double Cable-Sphere"
b. Minnesota Flex Corp.
c. Mercer "200 Series"
d. Twin City Hose "MS2".

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Install all products per manufacturer's recommendations.

B. Provide vibration isolation as indicated on the drawings and as described herein.

C. Clean the surface below all mountings that are not bolted down and apply adhesive cement equal to Mason Type WG between mounting and floor. If movement occurs, bolt mountings down. Isolate bolts from baseplates with neoprene washers and bushings.

D. All static deflections listed in the drawings and specifications are the minimum acceptable actual deflection of the isolator under the weight of the installed equipment - not the maximum rated deflection of the isolator.

E. Support equipment to be mounted on structural steel frames with isolators under the frames or under brackets welded to the frames. Where frames are not needed, fasten isolators directly to the equipment.

F. Where a specific quantity of hangers is noted in these specifications, it shall mean hanger pairs for support points that require multiple hangers, such as rectangular ducts or pipes supported on a strut rack.

3.2 PIPE ISOLATION

A. The first five hangers from vibration-isolated equipment shall have spring isolators with the same static deflection as the equipment. Use type H1 as required for the specified deflection. The next five hangers shall be type H2.

B. For base mounted pumps without resilient mountings, the first five hangers shall be Type H1.

C. Install flexible connectors in all piping connected to vibration producing equipment. This includes all fans, base-mounted pumps, compressors, etc. Absence of flexible connectors on piping diagrams does not imply that they are not required.

D. Use Type FC1 where pressures are lower than 150 psi, temperatures are below 220°F , and the fluid handled is compatible with neoprene and EPDM.

E. Provide sufficient piping flexibility for vibrating refrigerant equipment, or furnish flexible connectors with appropriate temperature and pressure ratings.

F. Support piping to prevent extension of flexible connectors.

3.3 VIBRATION ISOLATION OF DUCTWORK

A. The first three hangers on all fan systems shall be Type H1 with at least 0.20" minimum static deflection.

3.4 VIBRATION ISOLATION SCHEDULE

A. Inline Pumps:

1. Base Type: NA
2. Isolator Type: M3  H2
3. Static Deflection: 0.75"
4. Flexible Connections: NA

B. Base-Mounted Pumps:

1. Base Type: NA
2. Isolator Type: NA
3. Static Deflection: NA
4. Flexible Connections: FC-1

C. AHU Fans:

1. Base Type: B1
2. Isolator Type: M3 and/or TR1
3. Static Deflection: Refer to ASHRAE Table
4. Flexible Connections: Per Section 23 33 00

D. Fan Coil Units/VRF Branch Boxes - Suspended

1. Hangers: H2
2. Isolator Type: Compressed Spring
3. Static Deflection: Refer to ASHRAE Table

END OF SECTION 23 05 48

SECTION 23 05 53 - HVAC IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Identification of products installed under Division 23.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. 3M

B. Bunting

C. Calpico

D. Craftmark

E. Emedco

F. Kolbi Industries

G. Seton

H. W.H. Brady

I. Marking Services.

2.2 MATERIALS

A. All pipe markers (purchased or stenciled) shall conform to ANSI A13.1. Marker lengths and letter sizes shall be at least the following:

| OD of Pipe or Insulation | Marker Length | Size of Letters |
|---|---|---|
| Up to and including 1-1/4" (32mm) | 8" (200 mm) | 1/2" (12 mm) |
| 1-1/2" (40 mm) to 2" (50 mm) | 8" (200 mm) | 3/4" (20 mm) |
| 2-1/2" (65 mm) to 6" (150 mm) | 12" (300 mm) | 1-1/4" (32 mm) |

Plastic tags may be used for outside diameters under 3/4" (20 mm)

B. Plastic Nameplates: Laminated three-layer phenolic with engraved black, 1/4" minimum letters on light contrasting background.

C. Plastic Tags: Minimum 1-1/2" square or round laminated three-layer phenolic with engraved, 1/4" minimum black letters on light contrasting background.

D. Plastic Pipe Markers: Semi-rigid plastic, preformed to fit around pipe or pipe covering; indicating flow direction and fluid conveyed.

E. Vinyl Pipe Markers: Colored vinyl with permanent pressure sensitive adhesive backing.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install all products per manufacturer's recommendations.

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

C. Valves:

1. All valves (except shutoff valves at equipment) shall have numbered tags.
2. Provide or replace numbered tags on all existing valves that are connected to new systems or that have been revised.
3. Provide all existing valves used to extend utilities to this project with numbered tags. Review tag numbering sequence with the Owner prior to ordering tags.
4. Secure tags with heavy duty key chain and brass "S" link or with mechanically fastened plastic straps.
5. Attach to handwheel or around valve stem. On lever operated valves, drill the lever to attach tags.
6. Number all tags and show the service of the pipe.
7. Provide one Plexiglas framed valve directory listing all valves, with respective tag numbers, uses and locations. Mount directory in location chosen by the Architect/Engineer.

D. Pipe Markers:

1. Adhesive Backed Markers: Use Brady Style 1, 2, or 3 on pipes 3" diameter and larger. Use Brady Style 4, 6, or 8 on pipes under 3" diameter. Similar styles by other listed manufacturers are acceptable. Secure all markers at both ends with a wrap of pressure sensitive tape completely around the pipe.
2. Snap-on Markers: Use Seton "Setmark" on pipes up to 5-7/8" OD. Use Seton "Setmark" with nylon or Velcro ties for pipes 6" OD and over. Similar styles by other listed manufacturers are acceptable.
3. Apply markers and arrows in the following locations where clearly visible:

    a. At each valve.
    b. On both sides of walls that pipes penetrate.
    c. At least every 20 feet along all pipes.
    d. On each riser and each leg of each "T" joint.
    e. At least once in every room and each story traversed.

E. Equipment:

1. All equipment not easily identifiable such as controls, relays, gauges, etc.; and all equipment in an area remote from its function such as air handling units, exhaust fans, filters, reheat coils, dampers, etc.; shall have nameplates or plastic tags listing name, function, and drawing symbol. Do not label exposed equipment in public areas.
2. Fasten nameplates or plastic tags with stainless steel self-tapping screws or permanently bonding cement.
3. Mechanical equipment that is not covered by the U.S. National Appliance Energy Conservation Act (NAECA) of 1987 shall carry a permanent label installed by the manufacturer stating that the equipment complies with the requirements of ASHRAE 90.1.

F. Miscellaneous:

1. Attach self-adhesive vinyl labels at all duct access doors used to reset fusible links or actuators on fire, fire/smoke, or smoke dampers. Lettering shall be a minimum of 1/2" high. Labels shall indicate damper type.
2. Provide engraved plastic tags at all hydronic or steam system make-up water meters.

3.2 SCHEDULE

A. Pipes to be marked shall be labeled with text as follows, regardless of which method or material is used:

1. STEAM - 30 PSI: Black lettering; yellow background
2. STEAM - 15 PSI: Black lettering; yellow background
3. HEATING WATER SUPPLY: White lettering; green background
4. HEATING WATER RETURN: White lettering; green background
5. VACUUM CONDENSATE: Black lettering; yellow background
6. CHILLED WATER SUPPLY: White lettering; green background
7. CHILLED WATER RETURN: White lettering; green background
8. CONDENSATE DRAIN: White lettering; green background
9. NATURAL GAS: Black lettering; yellow background
10. REFRIGERANT LIQUID: White lettering; purple background
11. REFRIGERANT SUCTION: White lettering; purple background
12. REFRIGERANT HOT GAS: White lettering; purple background

B. Steam pipe markers shall include operating steam pressure within pipes shown above.

END OF SECTION 23 05 53

SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Testing, adjusting, and balancing of air systems.

B. Testing, adjusting, and balancing of heating systems.

C. Testing, adjusting, and balancing of cooling systems.

D. Testing, adjusting, and balancing of energy recovery systems.

1.2 QUALITY ASSURANCE

A. Agency shall be a company specializing in the adjusting and balancing of systems specified in this section with minimum three years' experience. Perform work under supervision of AABC Certified Test and Balance Engineer, NEBB Certified Testing, Balancing and Adjusting Supervisor, SMARTA Certified Air and Hydronic Balancer, or TABB Certified Supervisor.

B. Work shall be performed in accordance with the requirements of the references listed at the start of this section.

1.3 REFERENCES

A. AABC - National Standards for Total System Balance, Seventh Edition.

B. ADC - Test Code for Grilles, Registers, and Diffusers.

C. AMCA - Publication 203-90; Field Performance Measurement of Fan Systems.

D. ASHRAE - 2019 HVAC Applications Handbook; Chapter 39, Testing, Adjusting and Balancing.

E. ASHRAE/ANSI - Standard 111-2008; Practices for Measurement, Testing, Adjusting and Balancing of Building HVAC&R Systems.

F. NEBB - Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems, Ninth Edition, 2019.

G. SMACNA - HVAC Systems; Testing, Adjusting and Balancing, Third Edition, 2002.

H. TABB - International Standards for Environmental Systems Balance.

1.4 SUBMITTALS

A. Submit copies of report forms, balancing procedures, and the name and qualifications of testing and balancing agency for approval within 30 days after award of Contract.

B. Electronic Copies:

1. Submit a certified copy of test reports to the Architect/Engineer for approval. Electronic copies shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Copies that are not legible will be returned to the Contractor for resubmittal. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
2. Electronic file size shall be limited to a maximum of 10MB. Larger files shall be divided into files that are clearly labeled as "1 of 2", "2 of 2", etc.
3. All text shall be searchable.
4. Bookmarks shall be used. All bookmark titles shall be an active link to the index page and index tabs.

1.5 REPORT FORMS

A. Submit reports on AABC, SMACNA or NEBB forms. Use custom forms approved by the Architect/Engineer when needed to supply specified information.

B. Include in the final report a schematic drawing showing each system component, including balancing devices, for each system. Each drawing shall be included with the test reports required for that system. The schematic drawings shall identify all testing points and cross-reference these points to the report forms and procedures.

C. Refer to PART 4 for required reports.

1.6 WARRANTY/GUARANTEE

A. The TAB Contractor shall include an extended warranty of 90 days after owner receipt of a completed balancing report, during which time the Owner may request a recheck of terminals, or resetting of any outlet, coil, or device listed in the test report. This warranty shall provide a minimum of 24 manhours of onsite service time. If it is determined that the new test results are not within the design criteria, the balancer shall rebalance the system according to design criteria.

B. Warranty/Guarantee must meet one of the following programs: TABB International Quality Assurance Program, AABC National Project Performance Guarantee, NEBB's Conformance Certification.

1.7 SCHEDULING

A. Coordinate schedule with other trades. Provide a minimum of seven days' notice to all trades and the Architect/Engineer prior to performing each test.

B. Project will be constructed in the summer of 2024 if material is not able to be procured in 2023. Provide balancing report when complete.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. All procedures must conform to a published standard listed in the References article of this section. All equipment shall be adjusted in accordance with the manufacturer's recommendations. Any system not listed in this specification but installed under the contract documents shall be balanced using a procedure from a published standard listed in the References article.

B. The Balancing Contractor shall incorporate all pertinent documented construction changes (e.g. submittals/shop drawings, change orders, RFIs, ASIs, etc.) and include in the balancing report.

C. Recorded data shall represent actual measured or observed conditions.

D. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing is complete, close probe holes and patch insulation with new materials as specified. Restore vapor barrier and finish as specified.

E. Permanently mark setting of valves, dampers, and other adjustment devices allowing for settings to be restored. Set and lock memory stops.

F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, plugging test holes, and restoring thermostats to specified settings.

G. Installations with systems consisting of multiple components shall be balanced with all system components operating.

3.2 EXAMINATION

A. Before beginning work, verify that systems are complete and operable. Ensure the following:

1. General Equipment Requirements:

    a. Equipment is safe to operate and in normal condition.
    b. Equipment with moving parts is properly lubricated.
    c. Temperature control systems are complete and operable.
    d. Proper thermal overload protection is in place for electrical equipment.
    e. Direction of rotation of all fans and pumps is correct.
    f. Access doors are closed and end caps are in place.

2. Duct System Requirements:

    a. All filters are clean and in place. If required, install temporary media.
    b. Duct systems are clean and free of debris.
    c. Manual volume dampers are in place, functional and open.

d. Air outlets are installed and connected.
e. Duct system leakage has been minimized.

3. Pipe System Requirements:

a. Coil fins have been cleaned and combed.
b. Hydronic systems have been cleaned, filled, and vented.
c. Strainer screens are clean and in place.
d. Shutoff, throttling and balancing valves are open.

B. Report any defects or deficiencies to Architect/Engineer.

C. Promptly report items that are abnormal or prevent proper balancing.

D. If, for design reasons, system cannot be properly balanced, report as soon as observed.

E. Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to the Architect/Engineer for spot checks during testing.

B. Instruments shall be calibrated within six months of testing performed for project, or more recently if recommended by the instrument manufacturer.

3.4 INSTALLATION TOLERANCES

A. ± 10% of scheduled values:

1. Adjust air inlets and outlets to ± 10% of scheduled values.
2. Adjust piping systems to ±10% of design values.

B. Adjust supply, return, and exhaust air-handling systems to +10% / -5% of scheduled values.

3.5 ADJUSTING

A. After adjustment, take measurements to verify balance has not been disrupted or that disruption has been rectified.

B. Once balancing of systems is complete, at least one damper or valve must be 100% open.

C. After testing, adjusting and balancing are complete, operate each system and randomly check measurements to verify system is operating as reported in the report. Document any discrepancies.

D. Contractor responsible for each motor shall also be responsible for replacement sheaves. Coordinate with contractor.

E. Contractor responsible for pump shall trim impeller to final duty point as instructed by this contractor on all pumps not driven by a VFD. Coordinate with contractor.

3.6 SUBMISSION OF REPORTS

A. Fill in test results on appropriate forms.

PART 4 - SYSTEMS TO BE TESTED, ADJUSTED AND BALANCED

4.1 Verification of existing systems.

A. Where indicated on the drawings, perform a pre-balance of systems serving the area of construction prior to the start of any other work. Do not make adjustments to the systems. If the systems are not operating at maximum capacity, temporarily drive system to maximum and take readings for the system. Return the system to its original state when measurements are complete.

B. Report findings to Architect/Engineer on standard forms.

4.2 GENERAL REQUIREMENTS

A. Title Page:

1. Project name.
2. Project location.
3. Project Architect.
4. Project Engineer (IMEG Corp.).
5. Project General Contractor.
6. TAB Company name, address, phone number.
7. TAB Supervisor's name and certification number.
8. TAB Supervisor's signature and date.
9. Report date.

B. Report Index

C. General Information:

1. Test conditions.
2. Nomenclature used throughout report.
3. Notable system characteristics/discrepancies from design.
4. Test standards followed.
5. Any deficiencies noted.
6. Quality assurance statement.

D. Instrument List:

1. Instrument.
2. Manufacturer, model, and serial number.
3. Range.
4. Calibration date.

4.3 AIR SYSTEMS

A. Duct Leakage Test:

1. Air system and fan.
2. Leakage class.
3. Test pressure.
4. Construction pressure.
5. Flow rate (cfm): specified and actual.
6. Leakage (refer to Section 23 31 00 in the specifications): specified and actual.
7. Statement that fire dampers, reheat coils and other accessories were included in the test.
8. Pass or Fail.
9. Test performed by.
10. Test witnessed by.

B. Air Moving Equipment:

1. General Requirements:

a. Drawing symbol.
b. Location.
c. Manufacturer, model, arrangement, class, discharge.
d. Fan RPM.
e. Multiple RPM fan curve with operating point marked. (Obtain from equipment supplier).
f. Final frequency of motor at maximum flow rate (on fans driven by VFD).

2. Flow Rate:

a. Supply flow rate (cfm): specified and actual.
b. Return flow rate (cfm): specified and actual.
c. Outside flow rate (cfm): specified and actual.
d. Exhaust flow rate (cfm): specified and actual.

3. Pressure Drop and Pressure:

a. Filter pressure drop: specified and actual.
b. Total static pressure: specified and actual. (Indicate if across fan or external to unit).
c. Inlet pressure.
d. Discharge pressure.

C. Fan Data:

1. Drawing symbol.
2. Location.
3. Manufacturer and model.
4. Flow rate (cfm): specified and actual.
5. Total static pressure: specified and actual. (Indicate measurement locations).
6. Inlet pressure.
7. Discharge pressure.

8. Fan RPM.

D. Electric Motors:

1. Drawing symbol of equipment served.
2. Manufacturer, Model, Frame.
3. Nameplate: HP, phase, service factor, RPM, operating amps, efficiency.

E. Air Flow Measuring Station:

1. Drawing symbol.
2. Service.
3. Location.
4. Manufacturer and model.
5. Size.
6. Flow rate (cfm): specified and actual.
7. Pressure drop: specified and actual.

4.4 HEATING SYSTEMS

A. Pump Data (Primary and Secondary Heating Water Loop Pumps):

1. Existing drawing symbol or equipment TAG
2. Service.
3. Manufacturer, size, and model.
4. Impeller size: specified, actual, and final (if trimmed).
5. Flow Rate (gpm): specified and actual.
6. Pump Head: specified, operating and shutoff.
7. Suction Pressure: Operating and shutoff.
8. Final frequency of motor at maximum flow rate (on pumps driven by VFD).

B. Electric Motors (Associated Heating Water Loop Pump Motors):

1. Drawing symbol of equipment served.
2. Manufacturer, Model, Frame.
3. Nameplate: HP, phase, service factor, RPM, operating amps, efficiency.
4. Measured: Amps in each phase.

C. Heat Exchangers (not all items apply to all units):

1. General Requirements:

a. Drawing symbol.
b. Location.
c. Manufacturer and model.

2. Primary Heat Exchanger:

a. Steam pressure in exchanger: specified and actual.
b. Primary water entering temperature: specified and actual.
c. Primary water leaving temperature: specified and actual.

d. Primary water flow: specified and actual.
e. Primary water pressure drop: specified and actual.
f. Primary water Btuh (gpm x temperature drop x 500).Heating Coils:

1. General Requirements:

a. Drawing symbol.
b. Service.
c. Location.
d. Manufacturer and model.
e. Size.

2. Flow Rate:

a. Flow rate (cfm): specified and actual.
b. Water flow rate: specified and actual.

3. Temperature:

a. Entering air temperature: specified and actual.0
b. Leaving air temperature: specified and actual.
c. Entering water temperature: specified and actual.
d. Leaving water temperature: specified and actual.

4. Pressure Drop and Pressure:

a. Air pressure drop: specified and actual.
b. Steam pressure after valve: specified and actual.
c. Water pressure drop: specified and actual.

5. Energy:

a. Air Btuh (cfm x temp rise x 1.09).
b. Water Btuh (gpm x temp drop x 500). Repeat tests if not within 10% of air Btuh.

E. Terminal Heat Transfer Units:

1. General Requirement:

a. Drawing symbol.
b. Location.
c. Manufacturer and model.
d. Include air data only for forced air units.

2. Flow Rate:

a. Flow rate (cfm): specified and actual.
b. Water flow rate (cfm): specified and actual.

3. Temperature:

a. Entering air temperature: specified and actual.
b. Leaving air temperature: specified and actual.
c. Entering water temperature: specified and actual.
d. Leaving water temperature: specified and actual.

4. Energy:

a. Air Btuh (cfm x temperature rise x 1.09).
b. Water Btuh (gpm x temperature drop x 500). Repeat tests if not within 10% of air Btuh.

4.5 COOLING SYSTEMS

A. Pump Data:

1. General Requirements:

a. Drawing symbol.
b. Service.
c. Manufacturer, size, and model.
d. Impeller size: specified, actual, and final (if trimmed).
e. Final frequency of motor at maximum flow rate. (On pumps driven by VFD.)

2. Flow Rate:

a. Flow Rate (gpm): specified and actual.

3. Pressure Drop and Pressure:

a. Pump Head: specified, operating and shutoff.
b. Suction Pressure: Operating and shutoff.
c. Discharge Pressure: Operating and shutoff.

B. Electric Motors:

1. Drawing symbol of equipment served.
2. Manufacturer, Model, Frame.
3. Nameplate: HP, phase, service factor, RPM, operating amps, efficiency.
4. Measured: Amps for each phase.

C. Air Cooled Chillers:

1. General Requirements:

a. Drawing symbol.
b. Manufacturer and model.
c. Refrigerant type and capacity.
d. Starter type, size, and thermal protection.
e. Capacity: specified and actual.

2. Temperature:

a. Evaporator leaving water temperature: specified and actual.
b. Condenser entering air temperature.
c. Condenser leaving air temperature.

3. Pressure Drop and Pressure:

a. Evaporator pressure drop: specified and actual.

4. Flow Rate:

a. Evaporator water flow rate: specified and actual.

D. Direct Expansion Condensing Units:

1. General Requirements:

a. Drawing symbol.
b. Manufacturer and model.
c. Refrigerant type and capacity.
d. Capacity: specified and actual.

E. Cooling Coils:

1. General Requirements:

a. Drawing symbol.
b. Service.
c. Location.
d. Size.
e. Manufacturer and model.

2. Temperature:

a. Entering air DB temperature: specified and actual.
b. Entering air WB temperature: specified and actual.
c. Leaving air DB temperature: specified and actual.
d. Leaving air WB temperature: specified and actual.
e. Entering water temperature: specified and actual.
f. Leaving water temperature: specified and actual.

3. Flow Rate:

a. Flow rate (cfm): specified and actual.
b. Water flow rate (gpm): specified and actual.

4. Pressure Drop and Pressure:

a. Water pressure drop: specified and actual.
b. Air pressure drop: specified and actual.

F. Terminal Heat Transfer Units:

1. General Requirements:

    a. Drawing symbol.
    b. Location.
    c. Manufacturer and model.
    d. Include air data only for forced air units.

2. Temperature:

    a. Entering air DB temperature: specified and actual.
    b. Leaving air DB temperature: specified and actual.
    c. Entering water temperature: specified and actual.
    d. Leaving water temperature: specified and actual.

3. Flow rate:

    a. Flow rate (cfm): specified and actual.
    b. Water flow (gpm): specified and actual.

4.6 ENERGY RECOVERY SYSTEMS

A. Air Systems - Air energy recovery devices shall be tested at ambient temperatures of less than 40°F or greater than 85°F.

1. Energy Recovery Wheel:

    a. General Requirements:

        1) Drawing Symbol.
        2) Location.
        3) Wheel RPM.

    b. Primary Air:

        1) Primary Entering Air Temperature.
        2) Primary Leaving Air Temperature.
        3) Primary Air Pressure Drop.
        4) Primary Air Flow Rate (cfm).

    c. Secondary Air:

        1) Secondary Entering Air Temperature.
        2) Secondary Leaving Air Temperature.
        3) Secondary Air Pressure Drop.
        4) Secondary Air Flow Rate (cfm).

2. Air to Air Plate Exchanger:

    a. General Requirements:

        1) Drawing Symbol

2) Location.

b. Primary Air:

1) Primary Entering Air Temperature.
2) Primary Leaving Air Temperature.
3) Primary Air Flow Rate (cfm).
4) Primary Air Pressure Drop.

c. Secondary Air:

1) Secondary Entering Air Temperature.
2) Secondary Leaving Air Temperature.
3) Secondary Air Flow Rate (cfm).
4) Secondary Air Pressure Drop.

END OF SECTION 23 05 93

SECTION 23 07 13 - DUCTWORK INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Ductwork Insulation.

B. Insulation Jackets.

1.2 QUALITY ASSURANCE

A. Applicator: Company specializing in ductwork insulation application with five years minimum experience. When requested, installer shall submit manufacturer's certificate indicating qualifications.

B. Materials:

1. Flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255, or UL 723.
2. Fungal Resistance: No growth when tested in accordance with ASTM G21 (antifungal test).
3. Rated velocity on coated air side for air erosion in accordance with UL 181 at 5,000 fpm minimum.

C. Adhesives: UL listed, meeting NFPA 90A/90B requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Type A: Flexible Fiberglass - Outside Wrap; ANSI/ASTM C553; commercial grade; 0.28 / 0.26 (Out-Of-Package/Installed-Compressed 25%) maximum 'K' value at 75°F; foil scrim Kraft facing, 1.0 lb./cu. ft. density. Submit both "Out of Package" and "Installed-Compressed 25%" K and R-values.

B. Type E: Double wall ductwork insulation; fiberglass; 0.27 maximum 'K' value at 75°F mean temperature; 1.5 lb/cu ft density. Roof ductwork providing conditioned air to the interior of the building.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install materials in accordance with manufacturer's instructions, codes, and industry standards.

B. Install materials after ductwork has been tested.

C. Clean surfaces for adhesives.

D. Provide insulation with vapor barrier when air conveyed may be below ambient temperature.

E. Exterior Duct Wrap - Flexible, Type A:

1. Apply with edges tightly butted.
2. Cut slightly longer than perimeter of duct to insure full thickness at corners. Do not wrap excessively tight.
3. Seal joints with adhesive backed tape.
4. Apply so insulation conforms uniformly and firmly to duct.
5. Provide high-density insulation inserts at trapeze duct hangers and straps to prevent crushing of insulation. Maintain continuous vapor barrier through the hanger.
6. Seal all penetrations of the vapor barrier by strap hangers or slip cable hangers with adhesive backed tape.
7. Tape all joints with Royal Tapes #RT 350 (216-439-7229), Venture Tape 1525CW, or Compac Type FSK. No substitutions will be accepted without written permission from the Architect/Engineer.
8. Press tape tightly to the duct covering with a squeegee for a tight continuous seal. Fish mouths and loose tape edges are not acceptable.
9. Staples may be used, but must be covered with tape.
10. Vapor barrier must be continuous.
11. Mechanically fasten on 12" centers at bottom of ducts over 24" wide and on all sides of vertical ducts.

F. Double-Wall Ductwork Insulation - Type E:

1. Install insulation per manufacturer's recommendations.
2. Duct dimensions given are net inside dimensions of inner wall.

G. Continue insulation with vapor barrier through penetrations unless code prohibits.

H. Provide 2" wide, 24" high, 26 gauge, galvanized sheet metal corner protection angles for all externally insulated ductwork extending to a floor or curb.

3.2 SCHEDULE

A. Refer to Section 23 31 00 for scheduling of insulation.

END OF SECTION 23 07 13

SECTION 23 07 16 - HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Equipment Insulation.

B. Equipment Insulation Finishes.

1.2 QUALITY ASSURANCE

A. Applicator: Company specializing in insulation application with five years minimum experience.

B. Materials: Flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255, or UL 723 (where required).

PART 2 - PRODUCTS

2.1 INSULATION

A. Type C: Glass Fiber Blanket; ANSI/ASTM C612; 0.40 maximum 'K' value at 300°F ; 2.5 lb/cu ft. ; suitable to 850°F , with all service jacket (ASJ) vapor retarder jacket having 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723).

B. Type D: Glass Fiber Board; ANSI/ASTM C612; 0.28 maximum 'K' value at 200°F ; 6.0 lb/cu ft ; suitable to 850°F , 25/50 flame spread/smoke developed when tested in accordance with ASTM E84 (UL 723).

C. Type E: EPDM (NBR/PVC Blend is not permitted) elastomeric cellular foam; ANSI/ASTM C534; flexible plastic; 0.25 maximum 'K' value at 75°F , 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723). Maximum 1" thick per layer where multiple layers are specified.

D. Type F: Semi-Rigid Mineral Wool Fiberboard; ANSI/ASTM C612; 0.30 maximum 'K' value at 200°F ; suitable to 1200°F .

2.2 INSULATION FINISHES

A. Type 1: Glass Fabric; ASTM D1668, woven glass fabric with two coats of mastic approved for insulation type. Use vapor barrier mastics that are approved for both indoor and outdoor use on insulation systems covering surfaces having temperatures less than 70°F and having maximum 0.013 perms/inch ) rating at 0.043 inch dry-film thickness when tested in accordance with ASTM E-96 Procedure B (Foster 30-80 or approved equivalent). Use breather mastics that are approved for both indoor and outdoor use on insulation systems covering surfaces having temperatures 70°F or greater (Foster 35-00 or approved equivalent).

B. Type 2: All Service Jacket; ASTM C921; Factory or Field Applied; all-purpose polymer or polypropylene service jacket; Beach puncture resistance ratio of at least 50 units. Tensile strength: 35 psi minimum. Seal all joints with manufacturer approved tape and adhesive to maintain vapor barrier. Indoor use only, if used outdoors add type 4 finish.

C. Type 3: Flexible Elastomeric Thermal Insulation; After adhesive has fully cured, apply two coats of latex enamel paint approved by insulation manufacturer for outdoor use.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install all materials per manufacturer's instructions, codes and industry standards.

B. Maintain ambient temperatures and conditions required by manufacturers of adhesive and insulation.

C. Do not insulate factory insulated equipment.

D. Apply insulation as close as possible to equipment by grooving, scoring, and bevelling insulation. Secure to equipment with studs, pins, clips, adhesive, wires, or bands.

E. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier mastic.

F. Do not insulate over nameplates or ASME stamps. Bevel and seal insulation around such, unless omitting insulation would cause condensation problem. When such is the case, appropriate tagging shall be provided to identify the presence of these items.

G. When equipment with insulation requires periodic opening for maintenance, repair, or cleaning; install specially fabricated removable insulation sections. Covers shall have mechanical fasteners and be reusable.

H. Install 26 gauge galvanized sheet metal corner protection angles where insulation extends to the floor. Minimum 2" coverage of insulation.

I. Insulate all equipment surfaces that are not factory insulated and are intended to operate below 60°F and/or above 100°F . Verify insulation type and thickness with equipment manufacturer and Architect/Engineer.

J. Insulate all supports on equipment operating below ambient temperature.

### 3.2 INSULATION

A. Type C and D:

1. Apply with edges tightly butted and joints staggered.
2. Secure with welded pins and washers, 4" from each edge and 16" on center, or 1/2" x 0.015" galvanized steel bands, 12" on center.

B. Type E:

1. Apply with edges tightly butted and joints staggered. Install multiple layers if required thickness is greater than 1" thick.
2. Do not wrap sheet insulation around square corners, but cut and overlap insulation at corners to provide full insulation thickness on all sides. Seal all overlapping insulation surfaces with manufacturer approved adhesive.
3. Secure with manufacturer approved adhesive in accordance with installation instructions. Where applied to underside surfaces or on surfaces with temperatures 140°F and above, cover all surfaces with full application of adhesive. Seal all joints and seams with manufacturer approved adhesive.

3.3 SCHEDULE

A. Steam-to-Water Heat Exchanger (200 to 299°F ): 2" thick Type D; Finish 1 or 2.

B. Heating Water Air Separator/Coalescing Filter: 2" thick Type C, Finish 1 or 2.

C. Steam Condensate Receiver Tank: 2" thick Type D, Finish 1 or 2.

END OF SECTION 23 07 16

SECTION 23 07 19 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Piping Insulation.

B. Insulation Jackets.

1.2 QUALITY ASSURANCE

A. Applicator: Company specializing in piping insulation application with five years minimum experience.

B. Materials: Flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255, or UL 723 (where required). Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

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

D. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

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

PART 2 - PRODUCTS

2.1 INSULATION

A. Type A: Glass fiber; ANSI/ASTM C547; 0.24 maximum 'K' value at 75°F; non-combustible. All-purpose polymer or polypropylene service jacket, 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723).

1. Not allowed in Boiler Room and tunnels.

B. Type B: Flexible elastomeric foam insulation; closed-cell, sponge or expanded rubber (polyethylene type is not permitted); ANSI/ASTM C534, Grade 1 Type I for tubular materials; flexible plastic; 0.25 maximum 'K' value at 75°F, 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723). Maximum 1" thick per layer where multiple layers are specified.

C. Type E: Preformed rigid cellular polyisocyanurate insulation; ANSI/ASTM C591; maximum 'K' value of 0.19 at 75°F; density 4.0lb/ft; minimum compressive strength 95 psi parallel to rise; moisture resistant; 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723); suitable for -297°F to +300°F.

2.2 VAPOR BARRIER JACKETS

A. Polyvinylidene Chloride (PVDC or Saran) film and tape: Durable and highly moisture and moisture vapor resistant. Please refer to manufacturer's recommended installation guidelines.

2.3 JACKET COVERINGS

A. Aluminum Jackets: ASTM C1729; 0.016" thick (thicker where required by ASTM C1729); stucco embossed finish with Z edge seams and aluminum bands for outdoor use. Where colored jacket covers are called for, provide factory-applied hard film acrylic paint in color white.

B. Plastic Jackets and Fitting Covers: High impact, glossy white, 0.020" thick, self-extinguishing plastic. Suitable for use indoors or outdoors with ultraviolet inhibitors. Suitable for -40°F to 150°F. 25/50 maximum flame spread/smoke developed.

PART 3 - EXECUTION

3.1 PREPARATION

A. Install insulation after piping has been tested. Pipe shall be clean, dry and free of rust before applying insulation.

B. Patch and repair torn insulation. Paint to match adjacent insulation surface.

3.2 INSTALLATION

A. General Installation Requirements:

1. Install materials per manufacturer's instructions, building codes and industry standards.
2. Continue insulation with vapor barrier through penetrations. This applies to all insulated piping. Maintain fire rating of all penetrations.
3. All piping and insulation that does not meet 25/50 that is in an air plenum shall have written approval from the Authority Having Jurisdiction and the local fire department for authorization and materials approval. If approval has been allowed, the non-rated material shall be wrapped with a product that has been listed and labeled having a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested as a composite in accordance with ASTM E84 or UL 723.
4. On 1" and smaller piping routed through metal wall studs, provide a plastic grommet to protect the piping. The piping shall be insulated between the wall studs, and the insulation shall butt up to each stud.

B. Insulated Piping Operating Below 60°F:

1. Insulate fittings, valves, unions, flanges, flexible connections, flexible hoses, and expansion joints. Seal all penetrations of vapor barrier.

2. On piping operating below 60°F in locations that are not mechanically cooled (e.g., penthouses, mechanical rooms, tunnels, chases at exterior walls, etc.), Type B insulation shall be used.
3. All balance valves and strainers with fluid operating below 60°F shall be insulated with a removable plug wrapped with vapor barrier tape to allow access for reading and adjusting of the balancing valve and cleaning and servicing of the balancing valve.

C. Insulated Piping Operating Between 60°F and 140°F:

1. Do not insulate flanges and unions, but bevel and seal ends of insulation at such locations. Insulate all fittings, valves and strainers.

D. Insulated Piping Operating Above 140°F:

1. Insulate fittings, valves, flanges, float & thermostatic steam traps, and strainers. On gate valves, the insulation shall be extended to cover the entire valve bonnet, leaving only the portion of the stem that is above the bonnet and valve operator exposed.
2. All balance valves with fluid operating above 140°F shall be insulated and an opening shall be left in the insulation to allow for reading and adjusting the valve.
3. The use of removable insulation jackets is acceptable for insulating large and non-cylindrical shaped piping components (e.g., check valves, pressure regulating valves, calibrated balance valves, gate valve bonnets, F&T traps, strainers, line sets, and the like).

E. Refrigerant Piping:

1. On refrigerant piping (25°F and above) and not required to meet the 25/50 flame/smoke, provide at each strut or clevis support an insulation coupling to support pipe and to accept insulation thickness of adjoining insulation, to prevent insulation from sagging and crushing. The coupling shall be suitable for planned temperatures, use with specified pipe material, and shall be a 360°, one-piece cylindrical segment. Use mechanical fasteners where coupling cannot be installed on pipe during installation. Contractor shall apply adhesive to ends of insulation entering insulation coupling to maintain vapor barrier.

F. Exposed Piping:

1. Locate and cover seams in least visible locations.
2. Where exposed insulated piping extends above the floor, provide a sheet metal guard around the insulation extending 12" above the floor. Guard shall be 0.016" cylindrical smooth or stucco aluminum and shall fit tightly to the insulation.
3. Where piping is exposed in occupied spaces, provide a sheet metal guard around the piping up to 7' above finished floor. Piping within a protective shroud does not require metal insulation guard.

3.3 SUPPORT PROTECTION

A. Provide a shield on all insulated piping at each support between the insulation jacket and the support.

B. On all insulated piping greater than 1-1/2", provide shield with insulation insert of same thickness and contour as adjoining insulation at each support, between the pipe and insulation jacket, to prevent insulation from sagging and crushing. Inserts shall be as follows:

1. The insert shall be suitable for planned temperatures, be suitable for use with specific pipe material, and shall be a minimum 180° cylindrical segment the same length as metal shields. Inserts shall be:

   a. Molded hydrous calcium silicate (only use for pipes with operating temperatures above 90°F, with a minimum compressive strength of 100 psi is acceptable for pipe sizes 14" and below. For pipe sizes larger than 14", provide rolled steel plate in addition to the shield.
   b. Polyisocyanurate insulation (for pipes below 300°F with a minimum compressive strength of 24 psi is acceptable for pipe sizes 3" and below, minimum 60 psi for pipe sizes 4" to 10". For pipe sizes larger than 10", provide rolled steel plate in addition to the shield. Where insulation is installed on piping located within return air plenums and mechanical rooms, insulation shall have 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723).
   c. Cellular glass (for all temperature ranges) with a minimum compressive strength of 90 psi is acceptable for pipe sizes 14" and below. For pipe sizes larger than 14, provide rolled steel plate in addition to the shield.
   d. As an alternative to separate pipe insulation insert and saddle, properly sized manufactured integral rigid insulation insert and shield assemblies may be used.

      1) Products:

         a) Buckaroo CoolDry
         b) Cooper/B-Line Fig. B3380 through B3384
         c) Pipe Shields A1000, A2000

   e. Insulation Couplings:

      1) Molded thermoplastic slip coupling, -65°F to 275°F, sizes up to 4-1/8" OD, and receive insulation thickness up to 1". Suitable for use indoors or outdoors with UV stabilizers. Vertical insulation riser clamps shall have a 1,000lb vertical load rating. On cold pipes operating below 60°F, cover joint and coupling with vapor barrier mastic to ensure continuous vapor barrier.
      2) Horizontal Strut Mounted Insulated Pipe Manufacturers:

         a) Klo-Shure or equal

      3) Vertical Manufacturers:

         a) Manufacturers: Klo-Shure Titan or equal

   f. Rectangular blocks, plugs, or wood material are not acceptable.
   g. Temporary wood blocking may be used by the Piping Contractor for proper height; however, these must be removed and replaced with proper inserts by the Insulation Contractor. Refer to Supports and Anchors specification section for additional information.

C. Neatly finish insulation at supports, protrusions, and interruptions.

D. Install metal shields between all hangers or supports and the pipe insulation. Shields shall be galvanized sheet metal, half-round with flared edges. Adhere shields to insulation. On cold piping, seal the shields vapor-tight to the insulation as required to maintain the vapor barrier, or add separate vapor barrier jacket.

E. Shields shall be at least the following lengths and gauges:

| Pipe Size | Shield Size |
|---|---|
| 1/2" to 3-1/2" | 12" long x 18 gauge |
| 4" | 12" long x 16 gauge |
| 5” to 6" | 18" long x 16 gauge |

F. Ferrous hot piping 4 inches and larger, provide steel saddle at rollers as described in Section 23 05 29 "HVAC Supports and Anchors".

G. Minimum 1/4" rolled galvanized steel plates shall be provided in addition to the sleeves as reinforcement on large pipes to reduce point loading on roller, trapeze hanger and strut support locations depending on insulation compressive strength. Refer to section above for exact locations.

3.4 INSULATION

A. Type A Insulation:

1. All Service Jackets: Seal all longitudinal joints with self-seal laps using a single pressure sensitive adhesive system. Do not staple.
2. Insulation without self-seal lap may be used if installed with Benjamin Foster 85-20 or equivalent Chicago Mastic, 3M or Childers lap adhesive.
3. Apply insulation with laps on top of pipe.
4. Fittings, Valve Bodies and Flanges: For 4" and smaller pipes, insulate with 1 lb. density insulation wrapped under compression to a thickness equal to the adjacent pipe insulation. For pipes over 4", use mitered segments of pipe insulation. Finish with preformed plastic fitting covers. Secure fitting covers with pressure sensitive tape at each end. Overlap tape at least 2" on itself. For pipes operating below 60°F, seal fitting covers with vapor retarder mastic in addition to tape.

B. Type B Insulation:

1. Install per manufacturer™™s instructions or ASTM C1710.
2. Elastomeric Cellular Foam: Where possible, slip insulation over the open end of pipe without slitting. Seal all butt ends, longitudinal seams, and fittings with adhesive. At elbows and tees, use mitered connections. Do not compress or crush insulation at cemented joints. Joints shall be sealed completely and not pucker or wrinkle. Paint the outside of outdoor insulation with two coats of latex enamel paint recommended by the manufacturer.
3. Insulation Installation on Straight Pipes and Tubes:

a. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
b. Insulation must be installed in compression to allow for expansion and contraction. Insulation shall be pushed onto the pipe, never pulled. Stretching of insulation may result in open seams and joints.

4. Insulation Installation on Valves and Pipe Specialties:

a. Install preformed sections of same material as straight segments of pipe insulation when available.
b. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
c. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

C. Type D Insulation:

1. Use pre-molded half sections. Butt longitudinal and circumferential joints tightly. Wire in place with 16 gauge stainless steel wire on maximum 12" centers.
2. Apply in two layers. Stagger all joints between layers. Wire each layer individually.

3.5 JACKET COVER INSTALLATION

A. Metal Covering:

1. Provide vapor barrier as specified for insulation type. Cover with aluminum jacket covering with seams located on the bottom of horizontal piping. Include fittings, joints and valves.
2. Seal all interior and exterior butt joints with metal draw bands and sealant. Seal all exterior joints watertight.
3. Interior joints do not need to be sealed.
4. Use metal covering on the following pipes:

a. All exterior piping (does not include gas piping) .
b. Exposed vertical piping up to 7' above finished floor (does not include mechanical or Kitchen spaces)

5. Use colored aluminum jacket covers on the following pipes:

a. All exterior refrigeration piping.

B. Plastic Covering:

1. Provide vapor barrier as specified for insulation type. Cover with plastic jacket covering. Position seams to shed water.
2. Solvent weld all joints with manufacturer recommended cement.
3. Overlap all laps and butt joints 1-1/2" minimum. Repair any loose ends that do not seal securely. Solvent weld all fitting covers in the same manner. Final installation shall be watertight.
4. Use plastic insulation covering on all exposed pipes including, but not limited to:

a. All piping in mechanical rooms and all tunnels

b. All exposed piping in kitchen areas.

3.6 SCHEDULE

A. Refer to drawings for insulation schedule.

END OF SECTION 23 07 19

SECTION 23 09 00 - CONTROLS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Complete System of Automatic Controls.

B. Control Devices, Components, Wiring and Material.

C. Instructions for Owners.

D. Remodeling.

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum five years' experience.

B. TCC: Company specializing in the work of this section with minimum five years temperature control experience.

C. Technician: Minimum five years' experience installing commercial temperature control systems.

D. TCCs are limited to firms regularly employing a minimum of five full-time temperature control technicians within 100 miles of the job site.

1.3 SUBMITTALS

A. Equipment Coordination:

1. The Controls Contractor shall obtain approved equipment submittals from other contractors to determine equipment wiring connections, to choose appropriate controllers, and to provide programming.
2. Control valve selections shall be based on flow rates shown in approved shop drawings.
3. Coordinate the control interface of all equipment with the equipment manufacturers prior to submittal submission.

B. Shop Drawings:

1. Submit shop drawings per Section 23 05 00. In addition, submit an electronic copy of the shop drawings in Adobe Acrobat (.pdf) format to the Owner for review.
2. Cross-reference all control components and point names in a single table located at the beginning of the submittal with the identical nomenclature used in this section.
3. Submittal shall also include a trunk cable schematic diagram depicting operator workstations, control panel locations and a description of the communication type, media and protocol.

4. System Architecture: Provide riser diagrams of wiring between central control unit and all control panels. This shall include specific protocols associated with each level within the architecture. Identify all interface equipment between CPU and control panels. The architecture shall include interface requirements with other systems including, but not limited to, security systems, lighting control, fire alarm, elevator status, and power monitoring system.
5. Diagrams shall include:

    a. Wiring diagrams and layouts for each control panel showing all termination numbers.
    b. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show all interface wiring to the control system.
    c. Identification of all control components connected to emergency power.
    d. Schematic diagrams for all field sensors and controllers.
    e. A schematic diagram of each controlled system. The schematics shall have all control points labeled. The schematics shall graphically show the location of all control elements in the system.
    f. A schematic wiring diagram for each controlled system. Each schematic shall have all elements labeled. Where a control element is the same as that shown on the control system schematic, label it with the same name. Label all terminals.
    g. A tabular instrumentation list for each controlled system. The table shall show element name, type of device, manufacturer, model number and product data sheet number.
    h. All installation details and any other details required to demonstrate that the system will function properly.
    i. All interface requirements with other systems.

6. The network infrastructure shall conform to the published guidelines for wire type, length, number of nodes per channel, termination, and other relevant wiring and infrastructure criteria as published. The number of nodes per channel shall be no more than 80% of the defined segment (logical or physical) limit in order to provide future system enhancement with minimal infrastructure modifications.
7. Sequences: Submit a complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system. The wording of the control sequences in the submittal shall match verbatim that included in the construction documents to ensure there are no sequence deviations from that intended by the Architect/Engineer. Clearly highlight any deviations from the specified sequences on the submittals.
8. Points List Schedule: Submit a complete points list of all points to be connected to the TCS and FMCS. The points list for each system controller shall include both inputs and outputs (I/O), point number, the controlled device associated with the I/O point, the location of the I/O device, and reference drawings. Where a control point is the same as that shown on the control system schematic, label it with the same name. Points list shall specifically identify alarms, trends, event history, archive, totalization, graphic points, and all mapped points from other systems (security systems, lighting control, fire alarm, etc.). Provide points lists, point naming convention, and factory support information for systems provided and integrated into the FMCS.

9. Damper Schedule: Schedule shall include a separate line for each damper and a column for each of the damper attributes:

    a. Damper Identification Tag.
    b. Location.
    c. Damper Type.
    d. Damper Size.
    e. Duct Size.
    f. Arrangement.
    g. Blade Type.
    h. Velocity.
    i. Pressure Drop.
    j. Fail Position.
    k. Actuator Identification Tag.
    l. Actuator Type.
    m. Mounting.

10. Valve Schedule: Valve manufacturer shall size valves and create a valve schedule. Schedule shall include a separate line for each valve and a column for each of the valve attributes:

    a. Valve Identification Tag.
    b. Location.
    c. Valve Type.
    d. Valve Size.
    e. Pipe Size.
    f. Configuration.
    g. Flow Characteristics.
    h. Capacity.
    i. Valve CV.
    j. Design Pressure Drop.
    k. Pressure Drop at Design Flow.
    l. Fail Position.
    m. Close-off Pressure.
    n. Valve and Actuator Model Number and Type.

11. Airflow Measuring Station Schedule:

    a. The manufacturer's authorized representative shall prepare the airflow measuring station submittal, or review and approve in writing the submittal prepared by the TCC prior to submission to the Architect/Engineer and prior to installation. The representative shall review air handling equipment submittals and duct fabrication drawings to ensure that all AFMS locations meet the appropriate parameters to achieve proper installation and the specified accuracy. Comply with all manufacturer's installation requirements including straight up and downstream duct lengths. Install airflow straighteners if required by the manufacturer based on installation constraints. The Architect/Engineer shall be notified for approval of any deviations.
    b. Submit product data sheets for airflow measuring devices indicating minimum placement requirements, sensor density, sensor distribution, and installed accuracy to the host control system.

c. Submit installation, operation, and maintenance documentation.

12. Product Data Sheets: Required for each component that includes: unique identification tag that is consistent throughout the submittal, manufacturer's description, technical data, performance curves, installation/maintenance instructions, and other relevant items. When manufacturer's literature applies to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements.
13. Provide PICS files indicating the BACnet®functionality and configuration of each device.
14. Provide documentation of submitted products that have been tested and listed by the BACnet Testing Laboratory (BTL), or provide a letter on the manufacturer's company letterhead indicating the anticipated date by which testing is expected to be completed. If, for any reason, BTL testing and listing has not been completed, a written commitment to upgrade installed controls to a version that meets BTL testing and listing requirements if problems are found during BTL testing is required.
15. Graphic Display: Include a sample graphic of each system and component identified in the points list with a flowchart (site map) indicating how the graphics are to be linked to each other for system navigation. Graphics are completed on the WebSuper per Rockford Public Schools Contractor
16. Software: A list of operating system software, operator interface software, color graphic software, and third-party software. Graphics are completed on the WebSuper per Rockford Public Schools Contractor.
17. Control System Demonstration and Acceptance: Provide a description of the proposed process, along with all reports and checklists to be used.
18. Clearly identify work by others in the submittal.
19. Quantities of items submitted may be reviewed but are the responsibility of the Contractor to verify.

C. Operation and Maintenance Manual:

1. In addition to the requirements of Section 23 05 00, submit an electronic copy of the O&M manuals in PDF format.
2. Provide three complete sets of manuals.
3. Each O&M manual shall include:

    a. Table of contents with indexed tabs dividing information as outlined below.
    b. Definitions: List of all abbreviations and technical terms with definitions.
    c. Warranty Contacts: Names, addresses, and 24-hour telephone numbers of contractors installing equipment and controls and service representatives of each.
    d. Licenses, Guarantees, and Warranties: Provide documentation for all equipment and systems.
    e. System Components: Alphabetical list of all system components, with the name, address, and telephone number of the vendor.
    f. Operating Procedures: Include procedures for operating the control systems; logging on/off; enabling, assigning, and reporting alarms; generating reports; collection, displaying, and archiving of trended data; overriding computer control; event scheduling; backing up software and data files; and changing setpoints and other variables.

g. Programming: Description of the programming language (including syntax), statement descriptions (including algorithms and calculations used), point database creation and modification, program creation and modification, and use of the editor.
h. Engineering, Installation, and Maintenance: Explain how to design and install new points, panels, and other hardware; recommended preventive maintenance procedures for all system components, including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions; how to debug hardware problems; and how to repair or replace hardware. A list of recommended spare parts.
i. Original Software: Complete original issue CDs for all software provided, including operating systems, programming language, operator workstation software, and graphics software.
j. Software: One set of CDs containing an executable copy of all custom software created using the programming language, including the setpoints, tuning parameters, and object database.
k. Graphics: A glossary or icon symbol library detailing the function of each graphic icon and graphics creation and modification. One set of CDs containing files of all color graphic screens created for the project. Graphics are completed on the WebSuper per Rockford Public Schools contractor.

D. Training Manual:

1. Provide a course outline and training manuals for each training class.

E. Record Documents:

1. Submit record documentation per Section 23 05 00.
2. Provide a complete set of "as-built" drawings and application software on CDs. Provide drawings as AutoCAD or Visio compatible files. Provide two copies of the "as-built" drawings with revisions clearly indicated in addition to the documents on compact disk. All as-built drawings shall also be installed on the FMCS server in a dedicated directory. Provide all product data sheets in PDF format.
3. Submit two hard copies and one electronic copy of as-built versions of the shop drawings, including product data and record drawings with revisions clearly indicated. Provide floor plans showing actual locations of control components including panels, thermostats, sensors, and hardware.
4. Provide all completed testing and commissioning reports and checklists, along with all trend logs for each system identified in the points lists.
5. Submit printouts of all graphic screens with current values (temperatures, pressures, etc.) to the A/E verifying completion and proper operation of all points.

1.4 DELIVERY, STORAGE AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

B. Factory-Mounted Components: Where control devices specified in this section are indicated to be factory mounted on equipment, arrange for shipping control devices to unit manufacturer.

1.5 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Control Valves.

B. Flow Switches.

C. Temperature Sensor Sockets.

D. Gauge Taps.

E. Automatic Dampers.

F. Flow Meters.

1.6 AGENCY AND CODE APPROVALS

A. All products shall have the following agency approvals. Provide verification that the approvals exist for all submitted products with the submittal package.

1. UL-916; Energy Management Systems.
2. C-UL listed to Canadian Standards Association C22.2 No. 205-M1983 "Signal Equipment."
3. EMC Directive 89/336/EEC (European CE Mark).
4. FCC, Part 15, Subpart J, Class A Computing Devices.

1.7 ACRONYMS

A. Acronyms used in this specification are as follows:

1. B-AAC BACnet Advanced Application Controller
2. B-ASC BACnet Application Specific Controller
3. BTL BACnet Testing Laboratories
4. DDC Direct Digital Controls
5. FMCS Facility Management and Control System
6. GUI Graphic User Interface
7. IBC Interoperable BACnet Controller
8. IDC Interoperable Digital Controller
9. LAN Local Area Network
10. JACE (RPS specific) Network Controller
11. ODBC Open DataBase Connectivity
12. OOT Object Oriented Technology
13. OPC Open Connectivity via Open Standards
14. PICS Product Interoperability Compliance Statement
15. PMI Power Measurement Interface
16. POT Portable Operator's Terminal
17. TCC Temperature Control Contractor
18. TCS Temperature Control System
19. WAN Wide Area Network
20. WBI Web Browser Interface

1.8 SUMMARY

A. Extend Existing System (compatible with Owner control system):

1. Extend the existing Tridium FMCS for this project.
2. All controllers and accessories shall interface with the existing Tridium FMCS.

B. TCC shall furnish all labor, materials, equipment, and service necessary for a complete and operating Temperature Control System (TCS) and Facility Management and Control System (FMCS) using Direct Digital Controls as shown on the drawings and as described herein.

C. All labor, material, equipment and software not specifically referred to herein or on the plans that is required to meet the intent of this specification shall be provided without additional cost to the Owner.

D. The Owner shall be the named license holder of all software associated with any and all incremental work on the project.

1.9 SYSTEM DESCRIPTION

A. The entire TCS shall be comprised of a network of interoperable, standalone digital controllers communicating via the following protocol to an NAC. Temperature Control System products shall be as specified below.

B. The FMCS shall include Network Area Controller or Controllers (NAC) within each facility. The NAC shall connect to the Owner's local or wide area network, depending on configuration. Provide access to the system, either locally in each building or remotely from a central site or sites, through standard Web browsers, via the Internet, and/or via local area network.

C. Provide materials and labor necessary to connect factory supplied control components.

D. Provide central and remote hardware, software, and interconnecting wire and conduit.

E. The FMCS shall include automated alarming software capable of calling e-mail compatible cellular telephones and pagers. The e-mail alarm paging system shall be able to segregate users, time schedules, and equipment and be capable of being programmed by the Owner.

F. For the dedicated configuration tool provided, it is preferable that it be launched from within the applicable Network Management Software. If not, include any software required for controller configuration as a leave-behind tool with enough license capability to support the installation.

G. For each operator workstation provided, furnish one legal copy of all software tools, configuration tools, management tools, and utilities used during system commissioning and installation. All tools shall be readily available in the market. Contractor shall convey to the Owner all software tools and their legal licenses at project closeout.

1.10 SOFTWARE LICENSE AGREEMENT

A. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). In addition, the Owner shall receive ownership of all job-specific configuration documentation, data files, configuration tools, and application-level software developed for the project. This shall include, but is not limited to, all custom, job-specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use with the NAC, FMCS Server(s), and any related LAN/WAN/intranet and/or Internet connected routers and devices. Provide the Owner with all required IDs and passwords for access to any component or software program. The Owner shall determine which organizations shall be named in the SI organization ID ("orgid") of all software licenses. Owner shall be free to direct the modification of the "orgid" in any software license, regardless of supplier.

1.11 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It is this Contractor's responsibility to check the Contract Documents for possible conflicts between the Work of this section and that of other crafts in equipment location; pipe, duct and conduit runs; electrical outlets and fixtures; air diffusers; and structural and architectural features.

1.12 WARRANTY

A. Refer to Section 23 05 00 for warranty requirements.

B. Within the warranty period, any defects in the work provided under this section due to faulty materials, methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced by this Contractor at no expense to the Owner.

C. Warranty requirements include furnishing and installing all FMCS software upgrades issued by the manufacturer during the one-year warranty period.

D. Update all software and back-ups during warranty period and all user documentation on the Owner's archived software disks.

1.13 WARRANTY ACCESS

A. The Owner shall grant to this Contractor reasonable access to the TCS and FMCS during the warranty period.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. BACnet Protocol:

1. Distech Controls- Tridium
2. Alerton
3. Automated Logic: WebCTRL

4. Delta Controls: ORCA
5. Honeywell
6. Johnson Controls: Metasys Extended Architecture
7. KMC
8. Siemens Building Technologies: APOGEE
9. Schneider Electric - EcoStruxure Building Operation
10. Trane Tracer SC

2.2 SYSTEM ARCHITECTURE

A. General:

1. The Temperature Control System (TCS) and Facility Management Control System (FMCS) shall consist of a network of interoperable, standalone digital controllers, a computer system, graphic user interface software, printers, network devices, valves, dampers, sensors, and other devices as specified herein.

B. Open, Interoperable, Integrated Architectures:

1. All components and controllers supplied under this Division shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data are not acceptable.
2. The supplied system must be able to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs are not acceptable.
3. Hierarchical or "flat" topologies are required to have system response times as indicated below and to manage the flow and sharing of data without unduly burdening the customer's internal intranet network.

    a. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
    b. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

2.3 NETWORKS

A. The Local Area Network (LAN) shall be a 100 megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, and SOAP. Provide support for multiple Network Area Controllers (NACs), user workstations and, if specified, a local server.

B. Local area network minimum physical and media access requirements:

1. Ethernet; IEEE Standard 802.3.
2. Cable; 100 Base-T, UTP-8 wire, Category 6.
3. Minimum throughput; 100 Mbps.

C. Communication conduits shall not be installed closer than six feet from 110VAC or higher transformers or run parallel within six feet of electrical high-power cables. Route the cable as far from interference generating devices as possible. Where communication wire must cross 110VAC or higher wire, it must do so at right angles.

D. Ground all shields (earth ground) at one point only to eliminate ground loops. Provide all shield grounding at the controller location, with the shield at the sensor/device end of the applicable wire being left long and "safed" off in an appropriate manner.

E. There shall be no power wiring more than 30 VAC rms run in conduit with communications wiring. In cases where signal wiring is run in conduit with communication wiring, run all communication wiring and signal wiring using separate twisted pairs (24awg) in accordance with the manufacturer's wiring practices.

2.4 NETWORK AREA CONTROLLER (JACE)

A. The TCC shall supply one or more Network Area Controllers (NAC) as part of this contract. Number of NACs required depends on the type and quantity of devices provided under Divisions 23 and 26. The TCC shall determine the quantity and type of devices.

B. Each NAC shall provide the interface between the LAN or WAN and the field control devices and shall provide global supervisory control functions over the control devices connected to the NAC. It shall execute application control programs to provide:

1. Calendar functions.
2. Scheduling.
3. Trending.
4. Alarm monitoring and routing.
5. Time synchronization.
6. Integration of all controller data.
7. Network Management functions.

C. The Network Area Controller shall provide the following hardware features as a minimum:

1. One Ethernet Port - 10/100 Mbps.
2. One RS-232 port.
3. One LonWorks Interface Port - 78KB FTT-10A (for LonWorks systems only).
4. One RS-485 port.
5. Battery backup.
6. Flash memory for long-term data backup. (If battery backup or flash memory is not supplied, the controller shall contain a hard disk with at least 1 gigabyte storage capacity.)
7. The JACE must be capable of operation over a temperature range of 32°F to 122°F.
8. The JACE must be capable of withstanding storage temperatures of between 0°F and 158°F.
9. The JACE must be capable of operation over a humidity range of 5% RH to 95% RH, non-condensing.

D. The JACE shall provide multiple user access to the system and support for ODBC or SQL. Databases resident on the JACE shall be ODBC-compliant or must provide an ODBC data access mechanism to read and write data stored within it.

E. The JACE shall support standard Web browser access via the Internet or an intranet and a minimum of five (5) simultaneous users.

F. Event Alarm Notification and Actions:

1. The JACE shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
2. The JACE shall be able to route any alarm condition to any defined user location whether connected to a LAN, remote via dial-up telephone connection, or WAN.
3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including, but not limited to:

    a. Alarm
    b. Normal

4. Provide for the creation of a minimum of eight alarm classes with different routing and acknowledgement properties, e.g. security, HVAC, Fire, etc.
5. Provide timed (scheduled) routing of alarms by class, object, group, or node.
6. Provide alarm generation from binary object "runtime" and/or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.

G. Treat control equipment and network failures as alarms and annunciated.

H. Annunciate alarms in any of the following manners as defined by the user:

1. Screen message text.
2. E-mail of the complete alarm message to multiple recipients. Provide the ability to route and e-mail alarms based on:

    a. Day of week.
    b. Time of day.
    c. Recipient.

3. Pagers via paging services that initiate a page on receipt of e-mail message.
4. Graphic with flashing alarm object(s).
5. Printed message, routed directly to a dedicated alarm printer.

I. The FMCS shall record the following for each alarm:

1. Time and date.
2. Location (building, floor, zone, office number, etc.).
3. Equipment tag.
4. Acknowledge time, date, and user who issued acknowledgement.
5. Number of occurrences since last acknowledgement.

J. Give defined users proper access to acknowledge any alarm.

K. A log of all alarms shall be maintained by the JACE and/or a server (if configured in the system) and shall be available for review by the user.

L. Provide a "query" feature to allow review of specific alarms by user-defined parameters.

M. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.

N. An error log to record invalid property changes or commands shall be provided and available for review by the user.

2.5 BACNET FMCS

A. The intent of this specification is to provide a peer-to-peer networked, standalone, distributed control system with the capability to integrate ANSI/ASHRAE Standard 135-2001 BACnet, MODBUS, OPC, and other open and proprietary communication protocols in one open, interoperable system.

B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices in the system. Adherence to industry standards including the latest ANSI/ASHRAE Standard 135 (BACnet) to assure interoperability between all system components is required. For each BACnet device, the device supplier must provide a PICS document showing the installed device's compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet (BACnet Ethernet/IP) and/or RS-485 (BACnet MSTP).

C. Interoperable BACnet Controller (IBC):

1. Controls shall be microprocessor based Interoperable BACnet Controllers (IBC) in accordance with the latest ANSI/ASHRAE Standard 135. Provide IBCs for unit ventilators, fan coils, heat pumps, terminal air boxes (TAB) and other applications. The application control program shall reside in the same enclosure as the input/output circuitry that translates the sensor signals. Provide a PICS document showing the installed system's compliance level to ANSI/ASHRAE Standard 135. Minimum compliance is Level 3.
2. The IBCs shall be listed by the BACnet Testing Laboratory (BTL) as follows:

    a. BACnet Building Controller(s) (B-BC).
    b. BACnet Advanced Application Controller(s) (B-ACC).
    c. BACnet Application Specific Controller(s) (B-ASC).

3. The IBCs shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps.
4. Each IBC sensor shall connect directly to the IBC and shall not use any of the I/O points of the controller. The IBC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive. The IBC sensor shall provide a communications jack for connection to the BACnet communication trunk to which the IBC controller is connected. The IBC sensor, the connected controller, and all other devices on the BACnet bus shall be accessible by the POT.
5. All IBCs shall be fully application programmable and shall at all times maintain their BACnet Level 3 compliance. Controllers offering application selection only (non-programmable) require a 10% spare point capacity to be provided for all applications. Store all control sequences within or programmed into the IBC in non-volatile memory that does not depend on a battery to be retained.

6. The Contractor supplying the IBCs shall provide documentation for each device, with the following information at a minimum:

    a. BACnet Device; MAC address, name, type and instance number.
    b. BACnet Objects; name, type and instance number.

7. It is the responsibility of the Contractor to ensure that the proper BACnet objects are provided in each IBC.

D. Object Libraries:

1. A standard library of objects shall be included for development and setup of application logic, user interface displays, system services, and communication networks.
2. The objects in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.
3. In addition to the standard libraries specified here, the system supplier shall maintain an on-line accessible (over the Internet) library, available to all registered users, to provide new or updated objects and applications as they are developed.
4. All control objects shall conform to the control objects specified in the BACnet specification.
5. The library shall include applications or objects for the following functions, at a minimum:

    a. Scheduling Object: The schedule must conform to the schedule object as defined in the BACnet specification, providing seven-day plus holiday and temporary scheduling features and a minimum of 10 on/off events per day. Data entry to be by graphic sliders to speed creation and selection of on-off events.
    b. Calendar Object: The calendar must conform to the calendar object as defined in the BACnet specification, providing 12-month calendar features to allow for holiday or special event data entry. Data entry to be by graphic "point-and-click" selection. This object must be "linkable" to any or all scheduling objects for effective event control.
    c. Override Object: Provide override object that is capable of restarting equipment turned off by other energy saving programs to maintain occupant comfort or for equipment protection.
    d. Start-Stop Time Optimization Object: Provide a start-stop time optimization object to start equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled unoccupied time just far enough ahead to take advantage of the building's "flywheel" effect for energy savings. Provide automatic tuning of all start-stop time object properties based on historical performance.

e. Demand Limiting Object: Provide a demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, gas, etc.). The object shall be able to monitor a demand value and predict (using a sliding window prediction algorithm) the demand at the end of the user-defined interval period (1 to 60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user-defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment setpoints to provide the desired energy reduction. If the list of sheddable equipment is not enough to reduce the demand to below the setpoint, display a message on the user's screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand-limiting object shall restore the equipment that was shed in the reverse order in which it was shed. Each sheddable object shall have a minimum and maximum shed time property to provide both equipment protection and occupant comfort.

6. The library shall include control objects for the following functions:

a. Analog Input Object: Minimum requirement is to comply with the BACnet standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time delay filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.
b. Analog Output Object: Minimum requirement is to comply with the BACnet standard for data sharing.
c. Binary Input Object: Minimum requirement is to comply with the BACnet standard for data sharing. The user must be able to specify either input condition for alarming. This object must also include the capability to record equipment runtime by counting the amount of time the hardware input is in an "on" condition. The user must be able to specify either input condition as the "on" condition.
d. Binary Output Object: Minimum requirement is to comply with the BACnet standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as start-to-start delay must be provided. Incorporate the BACnet Command Prioritization priority scheme to allow multiple control applications to execute commands on this object with the highest priority command being invoked. Provide 16 levels of priority as a minimum. Systems not employing the BACnet method of contention resolution are not acceptable.
e. PID Control Loop Object: Minimum requirement is to comply with the BACnet standard for data sharing. Each individual property must be adjustable to allow proportional control only, or proportional with integral control, or proportional, integral and derivative control.
f. Comparison Object: Allow a minimum of two analog objects to be compared to select either the highest, lowest, or equality between the two linked inputs. Also, allow limits to be applied to the output value for alarm generation.
g. Math Object: Allow a minimum of four analog objects to be tested for the minimum or maximum, or the sum, difference, or average of linked objects. Also, allow limits to be applied to the output value for alarm generation.

h. Custom Programming Objects: Provide a blank object template for the creation of new custom objects to meet specific user application requirements. This object must provide a simple BASIC-like programming language that is used to define object behavior. Provide a library of functions including, but not limited to, math and logic functions and string manipulation. Also, provide a comprehensive on-line debug tool to allow complete testing of the new object. Allow new objects to be stored in the library for reuse.

i. Interlock Object: Provide an interlock object that provides a means of coordination of objects within a piece of equipment, such as an air handler or other similar types of equipment. An example is to link the return fan to the supply fan such that, when the supply fan is started, the return fan object is also started automatically without the user having to issue separate commands or to link each object to a schedule object. In addition, the control loops, damper objects, and alarm monitoring (such as return air, supply air, and mixed air temperature objects) will be inhibited from alarming during a user-defined period after startup to allow for stabilization. When the air handler is stopped, the interlocked return fan is also stopped, the outside air damper is closed, and other related objects within the air handler unit are inhibited from alarming, thereby eliminating nuisance alarms during the off period.

j. Temperature Override Object: Provide an object whose purpose is to override a binary output to an "on" state in the event a user-specified high or low limit value is exceeded. Link this object to the desired binary output object as well as to an analog object for temperature monitoring to cause the override to be enabled. This object will execute a start command at the Temperature Override level of start/stop command priority, unless changed by the user.

k. Composite Object: Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the "contained" application that are represented on the graphic shell of this container.

7. The object library shall include objects to support the integration of devices connected to the Network Controller (JACE). Provide the following as part of the standard library included with the programming software:

   a. For BACnet devices, provide the following objects:

      1) Analog In.
      2) Analog Out.
      3) Analog Value.
      4) Binary.
      5) Binary In.
      6) Binary Out.
      7) Binary Value.
      8) Multi-State In.
      9) Multi-State Out.
      10) Multi-State Value.
      11) Schedule Export.
      12) Calendar Export.
      13) Trend Export.
      14) Device.

b. For each BACnet object, provide the ability to assign the object a BACnet device and object instance number.
c. For BACnet devices, provide the following support at a minimum:

1) Segmentation.
2) Segmented Request.
3) Segmented Response.
4) Application Services.
5) Read Property.
6) Read Property Multiple.
7) Write Property.
8) Write Property Multiple.
9) Confirmed Event Notification.
10) Unconfirmed Event Notification.
11) Acknowledge Alarm.
12) Get Alarm Summary.
13) Who-has.
14) I-have.
15) Who-is.
16) I-am.
17) Subscribe COV.
18) Confirmed COV notification.
19) Unconfirmed COV notification.
20) Media Types.
21) Ethernet.
22) BACnet IP Annex J.
23) MSTP.
24) BACnet Broadcast Management Device (BBMD) function.
25) Routing.

## 2.6 TERMINAL AIR BOX (TAB) CONTROLLERS

A. FMCS Volume Controller: Electronic, furnished and installed by TCC. Boxes shall have pressure independent control to maintain constant air volume regardless of duct pressure changes up to 6 inches w.c. and shall be accurate down to 0.004" velocity pressure. Provide velocity and static sensor at box inlet for use by unit controller. Set boxes for maximum and minimum settings shown on the drawings. Refer to Section 23 36 00 for additional information.

B. The controller shall support various digital and analog inputs and outputs as needed for damper control, control valves, electric coils, airflow sensors, remote heating, occupancy sensors, etc. and shall be capable of independent occupancy scheduling.

C. Controller shall provide continuous zone temperature histories internal to device for up to 24 hours and perform its own limit and status monitoring and alarms to limit unnecessary communications.

D. Operator interface to any ASC point data or programs shall be through network resident programs or portable operator's terminal connected to the specific controller.

E. Store all system setpoints, proportional bands, control algorithms, and other programmable parameters such that a power failure of any duration does not necessitate reprogramming of the controller.

F. BACnet TAB controllers shall either be B-AAC devices or B-ASC devices as required to meet the performance and BTL listing.

2.7 DATA COLLECTION AND STORAGE (TRENDING REQUIREMENTS)

A. Shall be completed on WebSuper as referenced above

B. The JACE shall be able to collect data for any property of any object and store resident in the JACE that shall have, at a minimum, the following configurable properties:

1. Designating the log as interval or deviation.
2. For interval logs, configure the object for time of day, day of week and the sample collection interval.
3. For deviation logs, configure the object for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
4. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full or rollover the data on a first-in, first-out basis.

C. Store all log data in a relational database in the JACE that is accessible from a server (if the system is so configured) or a standard Web browser.

D. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.

E. All log data shall be available to the user in ALL the following data formats:

1. HTML.
2. XML.
3. Plain text.
4. Comma or tab separated values.

F. The JACE shall archive its log data either locally (to itself) or remotely to a server or other JACE on the network. Provide the ability to configure the following archiving properties:

1. Archive on time of day.
2. Archive on user-defined number of data stores in the log (buffer size).
3. Archive when log has reached its user-defined capacity of data stores.
4. Provide ability to clear logs once archived.

2.8 AUDIT LOG

A. Provide and maintain an audit log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the JACE), to another JACE on the network, or to a server. For each log entry, provide the following data:

1. Time and date.
2. User ID.
3. Change or activity: i.e., change setpoint, add or delete objects, commands, etc.

2.9 DATABASE BACKUP AND STORAGE

A. The JACE shall automatically backup its database on a user-defined time interval.

B. Store copies of the current database and, at the most, the recently saved database in the JACE. The age of the most recently saved database shall depend on the user-defined database save interval.

C. Store the JACE database in XML format to allow viewing and editing. Other formats are acceptable as long as XML format is supported.

2.10 GRAPHIC USER INTERFACE COMPUTER HARDWARE (LAPTOP COMPUTER)

A. Provide an Intel i7 processor based laptop computer with 8 GB RAM and 750-gigabyte minimum hard drive. It shall include a CD/DVD+/-R optical drive. Laptop computer shall be equipped with minimum 15" screen.

B. Connect to the FMCS network via a 10/100 Mbps Ethernet network interface card.

C. Provide a color laser system printer with a minimum 600 x 600-dpi resolution and 12 ppm print speed.

2.11 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. A UPS shall be provided for each of the following:

1. FMCS workstations and servers.
2. Network area controllers.

B. Provide a 120-volt 60 Hz line-interactive uninterruptible power supply with backup battery capacity for 5 minutes at 100% load. UPS shall have hot swappable batteries, automatic battery self-test and start-on-battery capabilities. Batteries shall be valve regulated, sealed lead acid type. UPS shall have sine wave shape output waveform. UPS shall be UL 1778 list and comply with FCC Part 15, Class A.

C. Manufacturers:

1. Sola/Hevi-Duty
2. Eaton Powerware
3. APC

2.12 SYSTEM PROGRAMMING

A. The GUI software shall perform system programming and graphic display engineering. Access to the GUI software shall be through password access as assigned by the system administrator.

B. Provide a library of control, application, and graphic objects to enable creation of all applications and user interface screens. Applications shall be created by selecting the control objects from the library, dragging or pasting them on the screen, and linking them together using a built-in graphic connection tool. Completed applications may be stored in the library for future use. GUI screens shall be created in the same fashion. Data for the user displays shall be obtained by graphically linking the user display objects to the application objects to provide "real-time" data updates. Any real-time data value or object property may be connected to display its current value on a user display. Provide all software tools or processes to create applications and user interface displays.

C. Programming Methods:

1. Provide the capability to copy objects from the supplied libraries or from a user-defined library to the user's application. Link objects with a graphic linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; e.g., internal, external, hardware, etc.
2. Configuration of each object shall be done through the object's property sheet using fill-in-the-blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration is not acceptable.
3. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.
4. All programming shall be done in real time. Systems requiring the uploading, editing, and downloading of database objects are not allowed.
5. The system shall support object duplication in a customer's database. An application, once configured, can be copied and pasted for easy reuse and duplication. All links, other than to the hardware, shall be maintained during duplication.

## 2.13 DDE DEVICE INTEGRATION

A. The JACE shall support the integration of device data via Dynamic Data Exchange (DDE) over the Ethernet network. The JACE shall act as a DDE client to another software application that functions as a DDE server.

B. Provide the required objects in the library included with the Graphic User Interface programming software to support the integration of these devices into the FMCS. Objects provided shall include, at a minimum:

1. DDE Generic AI Object.
2. DDE Generic AO Object.
3. DDE Generic BO Object.
4. DDE Generic BI Object.

2.14 CONTROL DAMPERS

A. Rectangular Control Dampers - Standard Construction:

1. Shall be licensed to bear the AMCA Certified Rating Seal.
2. Test leakage and pressure drop per AMCA 500.
3. Frame: Hat-shaped channel, minimum 12 gauge extruded aluminum, and minimum 4" deep. Caulk or weld seams to prevent leakage.
4. Blades: Minimum 12 gauge extruded aluminum airfoil design, minimum 6" wide, and overlapping blades and blade seals (overlapping blade seals only is unacceptable).
5. Shaft: Non-cylindrical, solid aluminum or zinc plated steel with opening in blade to match profile of shaft. Shaft shall be securely fastened to the blade and of sufficient length to mount direct-coupled actuator. Damper manufacturer shall provide drive pin extensions and outboard bearing support brackets as required.
6. Bearings: Acetal (Delrin/Celcon) inner bearing fixed to an aluminum shaft, rotating within a polycarbonate outer bearing inserted in the frame. Provide thrust bearings for vertical damper applications.
7. Blade Seals: Extruded silicone gaskets secured in an integral slot within the blade.
8. Side Seals: Stainless steel compression type or extruded silicone gasket secured in an integral slot within the frame.
9. Linkage: Shall be concealed in the frame, constructed of aluminum or corrosion-resistant zinc plated steel, and securely fastened to shaft. Blades linked for opposed operation, unless noted otherwise on the drawings. Blades shall close evenly. Use one direct-coupled actuator per damper section. Jack-shafting is not acceptable.
10. Size Limits: 48" maximum horizontal blade length, 24 square foot maximum area per damper. Total cross-sectional area of dampers in ducts shall be at least as large as the duct without the use of blank-off sections.
11. Maximum Leakage: Class 1A at 1" w.c. pressure differential for a 24" x 24" damper.
12. Maximum Pressure Drop for Opposed Blade Damper: 0.15" for 8,000 cfm through a 24" x 24" damper (2000 fpm).
13. Maximum Pressure Drop for Parallel Blade Damper: 0.08" for 8,000 cfm through a 24" x 24" damper (2000 fpm).

B. Thermally Insulated Control Damper:

1. Shall be licensed to bear the AMCA Certified Rating Seal.
2. Test leakage and pressure drop per AMCA 500.
3. Frame: Extruded aluminum, minimum 4" deep, 0.080" minimum thickness.

2.15 DAMPER ACTUATORS

A. Damper Actuators - Electronic - Spring Return:

1. Damper actuators shall be UL listed, electronic direct coupled with spring return to normal position for modulating or two-position control as noted in the sequence of control. Actuator shall be 24 VAC with proportional control, electronic overload protection to prevent actuator damage due to over-rotation and "V" bolt clamp with matching "V" toothed cradle (single bolt or setscrew fasteners not acceptable).

2. Following power interruption, spring return mechanism shall close the damper. Mechanical spring shall be rated for a minimum of 60,000 full cycles. Provide breathable membrane in actuator housing to compensate for pressure differential and allow for 95% non-condensing relative humidity in the airstream.
3. Mount actuators with motor outside of airstream whenever possible. Unit casings shall have housing with proper weather, corrosive, or explosion-proof construction as required by application.
4. Actuators shall be rated for 60,000 full cycles at rated torque with 2-year unconditional warranty. Size actuators per damper manufacturer's recommendations.
5. Provide end switches as required for the sequence of operation.
6. Provide analog feedback signal for positive position indication. Refer to FMCS points list.

## 2.16 HYDRONIC CONTROL VALVES

A. General:

1. Size two-way modulating valves to provide a pressure drop at full flow of 1 to 4 psi, except boiler three-way and cooling tower bypass valves shall not have a pressure drop over 2 psi.
2. Two-way valves shall be 100% tight-closing. Three-way valves shall be 100% tight-closing in both extreme positions.
3. Modulating two-way valves shall have equal percentage flow characteristics.
4. Piping geometry correction factors for Cv ratings shall be used and stated for ball valves, butterfly valves, or non-characterized valves.

B. Modulating:

1. Globe 1/2" to 2":

a. Design Pressure: 250 psi

1) Design Temperature: 212°F
2) Design Flow Differential Pressure Rating: 35 psi

b. Bronze or brass body, trim and plug; stainless steel stem; stainless steel or bronze seat; EPDM or PTFE packing; threaded ends.

2. Globe 2-1/2" to 6":

a. Design Pressure: 125 psi

1) Design Temperature: 250°F
2) Design Flow Differential Pressure Rating: 25 psi

b. Cast iron body, bronze or brass trim and plug; stainless steel stem; bronze seat; EPDM or PTFE packing; flanged ends.

3. Ball 2" and under:

a. Design Pressure: 400 psi

1) Design Temperature: 212°F
2) Design Flow Differential Pressure Rating: 35 psi

b. Bronze or brass body, nickel plated brass or stainless steel stem, chrome plated brass or stainless steel ball, PTFE or RTFE seats and seals, screwed ends (solder ends are acceptable only if rated for soldering in line with 470°F melting point of 95-5 solder).

4. Ball 3" to 6":

a. Design Pressure: 200 psi

1) Design Temperature: 212°F
2) Design Flow Differential Pressure Rating: 35 psi

b. Cast iron body, stainless steel stem, stainless steel full port ball, PTFE or RTFE seats and seals, flanged ends.

5. Butterfly 2-1/2" to 12":

a. Design Pressure: 125 psi

1) Design Temperature: -20°F to 212°F
2) Design Flow Differential Pressure Rating: 50 psi

b. Cast iron body, stainless steel stem with extended neck, aluminum-bronze or nickel-plated iron disc, EPDM seats and seals, fully lugged ends.

## 2.17 STEAM CONTROL VALVES

A. General:

1. Two-position valves shall have a maximum pressure drop equal to 10% of the inlet pressure.
2. Modulating control valves shall have modified linear characteristics.
3. Two modulating control valves in parallel shall have 1/3 - 2/3 capacities sequenced so that the smaller valve opens first.
4. The pressure drop through a modulating control valve with an inlet pressure less than or equal to 15 psig shall be equal to 80% of the inlet pressure. In no case shall the inlet pressure of the equipment after the valve be less than 2 psig, except for integral face and bypass coils where the inlet pressure after the valve shall not be less than 5 psig.
5. The pressure drop through modulating control valves with inlet pressures greater than 15 psig shall be required to provide outlet pressure of 1 psi above the scheduled or specified inlet pressure of the equipment served.
6. Piping geometry correction factors for Cv ratings shall be used and stated for ball valves, butterfly valves, or non-characterized valves.

## 2.18 VALVE ACTUATORS

A. Valve Actuators - Electronic:

1. Actuator shall be UL listed and provided with NEMA housing for applicable environment, electronic overload protection to prevent actuator damage due to over-rotation, and "V" bolt clamp with matching "V" toothed cradle (single bolt or setscrew fasteners not acceptable).
2. Actuators shall be rated for 60,000 full stroke cycles at rated torque. Stall motor not acceptable.
3. Tri-state/floating actuators shall have auto-zeroing function for realigning valve position.
4. Proportional actuator position shall be proportional to analog or pulse width modulating signal from electronic control system.
5. Spring return actuators shall have an internal spring return mechanism. Non-mechanical forms of fail-safe operation are not acceptable.
6. Provide analog feedback signal for positive position indication as required by control diagrams.

2.19 CONTROL INSTRUMENTATION

A. Temperature Measuring Devices:

1. Electric Thermostats:

a. Single Temperature - Line Voltage Electric: Integral manual ON/OFF/AUTO selector switch, minimum dead band of 5°F, concealed temperature adjustment, locking cover, rated for load, single or double pole as required.

2. Low Limit Switch:

a. Provide one foot of sensing element for each one square foot of coil area, maximum element length 25 feet, of the vapor tension type, so that any point along the entire length of measuring element can trigger the switch.
b. Provide 3" minimum radius capillary support clips at each turn.
c. Furnish each thermostat with one single pole, single throw normally-opened switch and one single pole, single throw normally-closed auxiliary switch.
d. Setpoint range shall be 15°F to 55°F with a permanent stop at 35°F.
e. Differential shall be fixed at approximately 5°F and supplied with manual reset.

B. Temperature Sensors:

1. Room Temperature Sensor:

a. Per Rockford Public School District - Sensor Only: Two-piece construction, ventilated plastic enclosure, off-white color, thermistor sensing element or resistance temperature device (RTD), 45°F to 90°F operating range, ± 0.50°F accuracy, no setpoint adjustment or override button.

2. Duct Temperature Sensor:

a. Thermistor or RTD type. Pneumatic transmitters with transducers are not acceptable.

3. Water Temperature Sensor:

a. Install in immersion wells. Separate thermometers as specified elsewhere, also of the immersion well type, shall be installed within 2 feet of each temperature sensor.

C. Humidity Measuring Devices:

1. Humidity Sensors:

a. Humidity Sensors: Fully electronic with no moving parts or parts requiring periodic service. Accuracy shall be minimum of 2.0 %RH accuracy from 0-90 %RH and 2.5 %RH accuracy from 90-100 %RH humidity at temperatures from 50°F to 104°F.
b. Humidity Sensors: Fully electronic with no moving parts or parts requiring periodic service. Accuracy shall be ± 2% of reading.

2. Humidistats:

a. Room Humidistats: Wall-mounted, proportioning type, with adjustable 2% RH throttling range, operating range from 30% to 80% at temperatures up to 110°F, cover with concealed setpoint. Accuracy shall be minimum of 1.5 %RH accuracy from 0-90 %RH and 2.5 %RH accuracy from 90-100 %RH at temperatures from 50°F to 104°F.
b. Duct Humidistats: Proportioning insertion type, with adjustable 2% RH throttling range and operating range from 20% to 80% at temperatures up to 150°F. Accuracy shall be minimum of 1.5 %RH accuracy from 0-90 %RH and 2.5 %RH accuracy from 90-100 %RH at temperatures from 50°F to 104°F.
c. High Limit Duct Humidistat: 2-position insertion type, with differential maximum 2% RH.

D. Combination Room Temperature/Humidity Sensors:

1. Wall-mounted two-piece construction, plastic enclosure, off-white color with temperature and humidity measurement, exposed single setpoint adjustment and occupant override. Large display with temperature and %RH readout display, occupied/unoccupied override button with LED.
2. Temperature Component: Thermistor sensing element or resistance temperature device (RTD), 45°F to 90°F operating range, ± 0.50°F accuracy.
3. Humidity Component: Proportioning type, with adjustable 2% RH throttling range, operating range from 0% to 90% at temperatures up to 110°F. Accuracy shall be minimum of 2.0 %RH accuracy from 0-90 %RH.

E. Enthalpy Sensors: Duct-mounted enthalpy sensor shall include solid state temperature and humidity sensors with electronics that shall output a 4-20 ma signal input to the controller upon a varying enthalpy (total heat) to enable economizer modes of operation when outside air enthalpy is suitable for free cooling.

F. Pressure Measuring Devices

1. Differential Pressure Switches:

a. Standard Pressure Switches:

1) Diaphragm-activated gauge with 4-3/4" dial, cast aluminum case, sealed interior, designed to resist shock and vibration, and rated for 15 psig.
2) Accuracy shall be ± 3% of full scale maximum throughout entire range at 70°F.
3) Provide mounting brackets, probes, and shutoff valves required for proper installation.
4) The range and service shall be as required for application or as noted on the drawings.
5) Provide two (2) photo-transistor-activated circuits and two (2) DPDT relays for both high or low limit alarms or controls.
6) Provide latching relays that require manual reset once activated.
7) Acceptable Manufacturer: Dwyer Photohelic Series 3000.

b. High Pressure Switches (Manual Reset):

1) Differential pressure switch with single pole, double-throw snap switch and enclosure.
2) Rated for pressure specified in sequence of control.
3) Electrical rating shall be 15 amps at 120-480 volts.
4) Setpoint adjustment shall be screw type located inside enclosure.
5) Provide optional manual reset for overpressure protection with all tubing, brackets, and adapters.
6) Repeatability: ± 3%.

2. Pressure Transmitters/Transducer:

a. Air-to-Air:

1) Provide transducer having the following minimum performance for measuring duct static pressure for VFD control or measuring differential pressure across filter banks:

a) Accuracy: ±1.0% FS
b) Non-Linearity, BFSL: ±0.96% FS
c) Hysteresis: 0.10% full scale
d) Non-Repeatability: 0.05% full scale
e) Thermal Effects (compensated range): 0°F to +150°F
f) Maximum Line Pressure: 10 PSI
g) Zero/Span Shift: 0.033%FS/°F
h) Long Term Stability: 0.5%FS/1year

2) Provide transducer with the following minimum performance for measuring differential pressure across piezometer fan inlet airflow measuring stations:

a) Unit shall come factory equipped with static tube attached.
b) Unit shall include: (1) LCD shall display differential pressure on face of sensor enclosure over the entire operational range, and (2) IPCC-rated polycarbonate enclosure with short circuit proof outputs and reverse polarity protected inputs.
c) Accuracy at 72°F: ±0.25% FS
d) Stability: ±0.25% full scale per year

e) Temperature Error: (1) Zero: ±0.025% full scale per °C, (2) Span: Maximum ±0.03% full scale per °C
f) Environmental Operating Range: 32°F to 140°F.
g) Overpressure: Proof: (1) 2 psi, (2) Burst: 3 psi
h) Humidity: 0% to 95% RH non-condensing.

b. Wet-to-Wet (uses include measuring hydronic system differential pressure for VFD control):

1) Unidirectional pressure range selected for appropriate range based on the application.
2) Provide transducer with minimum 250 psi high side proof pressure and minimum 60 psi low side proof pressure.
3) Case shall be constructed of stainless steel/aluminum and shall be equipped with 1/4" threaded connections. Wetted parts shall be constructed of 300 series stainless steel. Provide transducer with Viton and silicone O-rings for solutions containing water and/or glycol. Provide transducer with Buna-N O-rings for hydrocarbon solutions.
4) Provide transducer with factory assembled 3-valve manifold assembly to allow for field calibration of transducer.
5) Performance shall be as follows:

a) Accuracy: ±0.25% F.S.
b) Non-Linearity: ±0.20% F.S.
c) Hysteresis: 0.10%F.S.
d) Non-Repeatability: 0.05% F.S.
e) Compensated Temp Range: +30°F to +150°F
f) Long Term Stability: 0.5% F.S./year

G. Flow Measuring Devices:

1. Flow Switches:

a. Suitable for the intended application (water or air system).
b. Vane Operated Flow Switch: Vane motion shall activate a single pole, double throw snap switch.

2. Inline Electromagnetic Flow Meters:

a. General:

1) Each flow meter shall be of the electromagnetic type.

b. Service:

1) Condensate and Heating Water: Rated for minimum of 240°F service.

c. Electromagnetic Flow Tube:

1) Each meter shall be rated for system pressure and shall have adequate structural integrity for a flow rate equal to 150% of the scheduled maximum initial or future flow rate, whichever is greater.
2) Each meter shall have flanged connections to match piping pressure class, an outer body constructed of 316 stainless steel, a full line-size 304 stainless steel flow tube, 316 stainless steel electrodes, and a liner that is fully compatible with the chemical content of the flow media.

d. Transmitter:

1) Each meter shall incorporate an integral programmable transmitter that incorporates a digital display.
2) Each transmitter shall calculate and display flow rate and net totalized flow, along with associated engineering units (e.g., GPM and Gal.).
3) Each transmitter shall produce an analog output signal that is directly proportional to volumetric flow rate. This signal shall be scalable to indicate flow rate in either direction. In lieu of such bidirectional scalability, two separate pulsed outputs shall be provided. One shall indicate incremental flow in one direction, while the other indicates incremental flow in the opposite direction such that net totalized flow can be calculated remotely.
4) Unless scheduled or otherwise indicated, the initial span adjustment of each transmitter shall be 0-120% of the scheduled maximum flow rate.
5) Each transmitter shall incorporate self-diagnostics and test functions to permit internal checks of all outputs and displays, and to verify the accuracy of the unit and the integrity of the current loop without any external equipment.

e. Accuracy:

1) Non-billing Purposes: The accuracy of each meter/transmitter assembly shall be ± 0.5% of flow rate reading over a range of 3-15 feet/second fluid velocity, with a repeatability of 0.1%. Accuracy at 1 foot/second shall be ± 0.75%.

f. Display Unit:

1) Pair with Display Unit described below.

g. BTU Meter:

1) Pair with BTU Meter described below.

h. Calibration:

1) Each meter shall be calibrated on an NIST traceable flow stand at 1, 8, and 15 feet/second. Provide written documentation of calibration.

i. Installation and Startup:

1) Each meter assembly shall include detailed installation and operation instructions, including piping straight run requirements.

j. Warranty:

1) Each meter assembly shall carry a performance warranty of at least two years from the date of installation and startup. This warranty shall cover parts and labor for repair or replacement of the meter assembly. Performance during the warranty period shall satisfy the above-stated requirements for accuracy and repeatability.

k. Manufacturers:

1) ABB
2) Yokogawa
3) Rosemount
4) Onicon
5) Badger.

3. Airflow Measuring Stations:

a. In accordance with the requirements of LEED EQc1: Outdoor Air Delivery Monitoring, any AFMS used to measure outside air CFM shall have an accuracy of ±15% of the design minimum outdoor air flow rate (or better). The AFMS accuracy shall also comply with requirements outlined in the following paragraphs of this specification.

b. Duct Mounted Airflow Measuring Stations (AFMS) - Thermal Dispersion:

1) Provide airflow/temperature measurement devices where indicated on the plans.
2) Each AFMS shall consist of one or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.

a) Each sensor assembly shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
b) Thermitors shall be mounted in the sensor assembly using a marine-grade, waterproof epoxy. Thermistor leads shall be protected and not exposed to the environment.
c) Devices using chip-in-glass or diode-case chip thermistors are not acceptable.
d) Devices using less than two thermistors in each sensor assembly are not acceptable.
e) Devices using platinum wire RTDs are not acceptable.
f) Devices having electronic circuitry mounted in or at the sensor probe are not acceptable.
g) Pitot tubes and arrays are not acceptable.
h) Vortex shedding devices are not acceptable.

3) All Sensor Probes:

a) Each sensor assembly shall independently determine the velocity and temperature at its measurement point.

b) Each sensor assembly shall be calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST).
c) Airflow measuring station assembly accuracy shall be ± 2% of Reading over the entire operating airflow range. Temperature accuracy shall be ± 0.15° F between -20° F and 160° F.
d) The operating humidity range for each sensor probe shall be 0-99% RH (non-condensing).
e) Each sensor probe shall have an integral, UL listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter for each measurement location.
f) The number of probes shall be as recommended by the manufacturer to achieve the specified accuracy.

4) Duct and Plenum Probes:

a) Probes shall be constructed of extruded, gold anodized, 6063 aluminum tube. All wires within the aluminum tube shall be Kynar coated.
b) Probe assembly mounting brackets shall be constructed of 304 stainless steel.

5) Sensor Density:

| Area (sq.ft.) | Total # of Sensors Required |
|---|---|
| Less than 2 | 4 |
| 2 to less than 4 | 6 |
| 4 to less than 8 | 8 |
| 8 to less than 16 | 12 |
| ≥ 16 | 16 |

6) Transmitters:

a) The transmitter shall have an integral 16-character alphanumeric LCD display capable of simultaneously displaying individual airflow and temperature.
b) The transmitter shall be capable of field configuration and diagnostics using an on-board interface and LCD display.
c) The operating temperature range for the transmitter shall be -20° F to 120° F.
d) The transmitter shall be capable of communicating with other devices using one of the following interface options:
e) Option 1: Linear analog output signals for airflow and temperature: Field selectable, fuse protected and isolated, 0-10VDC/4-20mA (4-wire)
f) Option 2: RS-485: Field selectable BACnet-ARCNET, BACnet-MS/TP, Modbus-RTU or Johnson Controls N2-Bus. BACnet devices shall provide analog variables for airflow and temperature containing individual sensor airflow rate and temperature data.

g) Option 3: 10 Base-T Ethernet: Field selectable BACnet Ethernet, BACnet-IP, Modbus-TCP and TCP/IP. Provide dynamic link libraries and VBA functions to interface Ethernet devices to Microsoft Excel for remote monitoring of airflow and temperature using a Windows 2000 or Windows XP based PC.

c. Fan Inlet Airflow Measuring Stations (AFMS) - Thermal Dispersion:

1) Sensor assemblies shall be mounted on 304 stainless steel housings.
2) Mounting rods shall be field adjustable to fit the fan inlet and constructed of nickel plated steel.
3) Mounting feet shall be constructed of 304 stainless steel and securely riveted in place to prevent loosening over time due to vibration.
4) The operating airflow range shall be 0 to 10,000 FPM unless otherwise indicated on the plans.
5) Transmitters

a) The transmitter shall have an integral 16-character alphanumeric LCD display capable of simultaneously displaying individual airflow and temperature.
b) The transmitter shall be capable of field configuration and diagnostics using an on-board interface and LCD display.
c) The operating temperature range for the transmitter shall be -20° F to 120° F.
d) The transmitter shall be capable of communicating with other devices using one of the following interface options:
e) Option 1: Linear analog output signals for airflow and temperature: Field selectable, fuse protected and isolated, 0-10VDC/4-20mA (4-wire)
f) Option 2: RS-485: Field selectable BACnet-ARCNET, BACnet-MS/TP, Modbus-RTU or Johnson Controls N2-Bus. BACnet devices shall provide analog variables for airflow and temperature containing individual sensor airflow rate and temperature data.
g) Option 3: 10 Base-T Ethernet: Field selectable BACnet Ethernet, BACnet-IP, Modbus-TCP and TCP/IP. Provide dynamic link libraries and VBA functions to interface Ethernet devices to Microsoft Excel for remote monitoring of airflow and temperature using a Windows 2000 or Windows XP based PC.
h) Option 4: LonWorks Free Topology

6) The AFMS shall be UL listed as an entire assembly.

H. Current Measuring Devices:

1. Current Switches for Constant Speed Motors:

a. Digital device rated for amperage load of motor or device with split core design, adjustable high and low trip points, 600 VAC rms isolation, induced power from the monitored load, LED indicator lamps for output status and sensor power. The device shall sense overloading, belt-loss, and power failure with a single signal.

2. Current Switches for Motors Controlled by VFD:

    a. Digital device rated for amperage load of motor or device with split core design, factory programmed to detect motor undercurrent conditions on variable or constant volume loads, self-calibrating, positive status indication, LED indicator lamps, 600 VAC rms isolation, induced power from the monitored load with NO output. The current sensor shall store the motor current operating parameters in non-volatile memory and have a pushbutton reset to clear the memory if the operating parameters change or the sensor is moved to another load. The device shall sense overloading, belt-loss, and power failure with a single signal. The sensor shall be mounted on the load side of variable frequency drives.

I. Carbon Dioxide Sensors:

1. Microprocessor based non-dispersive infrared sensor with range of 0 to 2,000 ppm CO2 with ± 100 ppm accuracy, maximum drift (compensated) of ± 5% full scale in five years, VOC software and hardware sensing, duct mounting where applicable, 0-10V dc or 4-20 mA output directly proportional to ppm, adjustable alarm limit, membrane filter, and terminal block. The diffusion gas chamber in the sensor shall incorporate a reflective light pipe or wave guide surrounded by a gas permeable membrane that prevents particulate contamination of the sensor. Unit shall have selectable IAQ mode with output signal and sum of CO2 and VOC levels.

J. Miscellaneous Devices:

1. Application Specific Controller Power Supply:

    a. For use with terminal air box or fan coil unit or unit ventilator.
    b. Provide multiple enclosures with the following accessories and components as required to provide 24VAC power to terminal air boxes, differential pressure monitors, damper actuators, valve actuators, and other components and devices as required.
    c. NEMA-1 steel enclosures (12"x12"x6") with separate high and low voltage compartments and separate access covers.
    d. Either one 300 VA power supply with three 100 VA Class 2 outputs, or one 500 VA power supply with five 100 VA Class 2 outputs.
    e. Primary side shall receive 480/277/240/120 input to 24 VAC ungrounded, isolated output on the secondary side.
    f. Each secondary output shall include a 4 amp breaker, on/off switch, and LED indicator. Terminal blocks shall accept 16-22 AWG wire.
    g. Acceptable Manufacturer:

        1) RIB Functional Devices Model MSH300A-LVC or PSH500A-LVC

2. Control Relays:

    a. Form "C" contacts rated for the application with "push-to-test" contact transfer feature and an integral LED to indicate coil energization.
    b. Mount all relays and power supplies in a NEMA 1 enclosure beside the FMCS panel or controlled device and clearly label their functions.

3. Thermostat and Sensor Enclosures:

a. Heavy Duty Enclosure:

1) Perforated steel, tamperproof locking thermostat and control device enclosure.
2) Box shall be nominally 8"x6"x2" deep or sized as required to fit devices to be enclosed.
3) Perforated cover shall be 16 gauge steel with maximum 3/16" perforations on maximum 1/4" staggered centers for a 55% free area.
4) Secure to wall from inside of box. Cover shall be secured by tamperproof screws to frame.
5) Color shall match electrical devices. Verify color with the Electrical Contractor.

K. Outdoor Weather Station:

1. Outdoor rated ventilated plastic enclosure, off-white color, radiation shield including the following parameters.
2. Measured Parameters:

a. Temperature Sensor: Thermistor sensing element or resistance temperature device (RTD).

1) Operating Range: -40°F to 140°F
2) Accuracy: ± 0.54°F at 68°F

b. Humidity Sensors: Fully electronic with no moving parts or parts requiring periodic service.

1) Measurement Range: 0-100% RH
2) Accuracy:

a) ± 3% of reading from 0%-90% RH at 50°F to 86°F

3. Calculated Parameters:

a. Dew Point Temperature in °F
b. Wet Bulb Temperature in °F
c. Enthalpy. Enthalpy sensor shall output a 4-20 ma signal input to the controller upon a varying enthalpy (total heat) to enable economizer modes of operation when outside air enthalpy is suitable for free cooling.

2.20 CONDUIT AND BOXES

A. Conduit and Boxes: Refer to Electrical Section 26 05 33 for materials, sizing, and other requirements

B. Conduit and Box Identification (Color and Labeling):

1. Refer to the Temperature Control Contractor notes located on the temperature controls cover sheet for raceway and box color requirements.
2. Refer to Electrical Section 26 05 53 for raceway and box labeling requirements.

2.21 WIRE AND CABLE

A. Wire and Cable: Refer to Electrical Section 26 05 13 for wire and cable materials.

1. Wire and Cable Color: Refer to the Temperature Control Contractor notes located on the temperature controls cover sheet for wire and cable color requirements.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Verify that systems are ready to receive work. Beginning of installation means installer accepts existing conditions.

B. Install system and materials in accordance with manufacturer's instructions.

C. Drawings of the TCS and FMCS network are diagrammatic only. Any apparatus not shown but required to meet the intent of the project documents shall be furnished and installed without additional cost.

D. Install all operators, sensors, and control devices where accessible for service, adjustment, calibration, and repair. Do not install devices where blocked by piping or ductwork. Devices with manual reset or limit adjustments shall be installed below 6'-0" if practical to allow inspection without using a ladder.

E. Verify locations of wall-mounted devices (such as thermostats, temperature and humidity sensors, and other exposed sensors) with drawings and room details before installation. Coordinate mounting heights to be consistent with other wall-mounted devices. Maximum height above finished floor shall not exceed ADA mounting requirements.

F. Provide valves over 3/4" size with position indicators and pilot positioners where sequenced with other controls.

G. Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. One cabinet may accommodate more than one system in same equipment room.

H. After completion of installation, test and adjust control equipment.

I. Check calibration of instruments. Recalibrate or replace.

J. Furnish and install conduit, wire, and cable per the National Electric Code, unless noted otherwise in this section.

K. All controls associated with the proper operation of air handling units, pumps, or other mechanical equipment served by emergency power shall be connected to the emergency power system. Control components shall be powered from the optional standby branch of emergency power. In no instance shall panel be connected to the life safety branch of the emergency power system. Panels may be connected to a common 20 amp, 120 volt circuit provided the total load on the circuit does not exceed 16 amps. Circuit conductors shall be sized per the table below. All power connections to the control panels shall be performed by a licensed electrician at the cost of this Contractor. Submit circuit information (total amperage on circuit, conductors length, and panel) for control panels to the Architect/Engineer for approval.

| Circuit Load (Amps) | Circuit Max Length | Feeder Size |
|---|---|---|
| ≤ 5 | ≤ 200ft | 2#12 & 1#12 ground in 3/4" conduit. |
| ≤ 10 | ≤ 100ft | 2#12 & 1#12 ground in 3/4" conduit. |
| ≤ 16 | ≤ 75ft | 2#12 & 1#12 ground in 3/4" conduit. |
| ≤ 200 | ≤ 325ft | 2#10 & 1#10 ground in 3/4" conduit. |
| ≤ 100 | ≤ 160ft | 2#10 & 1#10 ground in 3/4" conduit. |
| ≤ 75 | ≤ 100ft | 2#10 & 1#10 ground in 3/4" conduit. |

L. All hardware, software, equipment, accessories, wiring (power and sensor), piping, relays, sensors, power supplies, transformers, and instrumentation required for a complete and operational FMCS system, but not shown on the electrical drawings, are the responsibility of the TCC.

M. Remodeling:

1. All room devices as indicated on the drawings shall be removed by this Contractor. The Contractor shall also prepare the wall for finishes. Preparing the wall shall include patching old anchor holes (after the anchoring device has been removed) and sanding the wall to remove old paint outlines remaining from original devices. The wall shall be painted to match the existing wall prior to the installation of the new room device. If wall covering requires patching, the Contractor shall furnish new wall covering to match existing. If new wall covering is not available to match existing, the Contractor shall furnish a white acrylic or Plexiglas plate, 1/4" thick and sized to cover the void.

N. Labels For Control Devices:

1. Provide labels indicating service of all control devices in panels and other locations.
2. Labels may be made with permanent marking pen in the control panels if clearly legible.
3. Use engraved labels for items outside panel such as outside air thermostats.
4. Labels are not required for room thermostats, damper actuators and other items where their function is obvious.

O. VFDs:

1. This project includes several variable frequency drives to control the flow of fans and/or pumps based on a control variable.
2. Verify output signal required, 4-20 mA or 0-10V dc, with the EC.

3. If VFD has a bypass feature, auxiliary contacts on the drive may not be used for motor status. A separate relay must be used to indicate motor rotation in either hand or auto positions.
4. If a separate current transmitter or switch is indicated for status, install this device between the VFD and the motor. In this case, the drive status may be connected to the auxiliary contacts in the VFD.
5. Some devices, such as low limits and fire alarm shutdown relays, must be hardwired to the fan motor. Make connections such that fan will shut down whether in hand or auto position if the unit has a bypass feature.

P. Airflow Stations:

1. The transmitter shall be installed at a location that is protected from weather, water, and vibration.
2. Mount transmitter where they can easily be read (36" to 66" above floor). Do not fasten transmitters directly to ductwork or compromise duct insulation.
3. The manufacturer's authorized representative shall visit the project site during construction prior to station installations to confirm all submitted sizes, mounting requirements and locations. Size adjustments shall be made at no additional cost. The representative shall meet on site with the TCC to support and train them on proper installation procedures and calibration.
4. Install labels at each sensor and transmitter identifying its service.

3.2 GRAPHIC DISPLAY

A. Create a customized graphic for each piece of equipment indicated on the itemized points list.

B. Components shall be arranged on graphic as installed in the field.

C. Include each graphic point listed in the itemized points list using real time data.

D. Provide a graphic representation of the following:

1. Where there are multiple buildings, color code the campus map by the systems serving that building. The building graphic shall be linked to the graphic for that building's systems.
2. Where there are multiple floors, provide color codes/designations for the areas served by each AHU and TAB by floor.
3. Where multiple AHUs serve one floor, color code the areas served by each AHU. The area shall be linked to the graphic for that area's AHU.
4. Provide an overall floor plan of each floor of the building color coded by zone linked to the TAB for that zone. The zone shall be linked to the graphic for that zone's TAB graphic.
5. Show the location of each thermostat on the floor plan.
6. Provide separate graphics showing the chilled and heating water system flow diagram. Show temperatures and flows on the flow diagram. Each piece of equipment shown on the flow diagram shall be linked to the graphic for that piece of equipment.
7. Provide a graphic showing the steam system flow diagram. Show pressures and flows on the flow diagram. Each piece of equipment shown on the flow diagram shall be linked to the graphic for that piece of equipment.

E. The FMCS shall include full graphic operator interface to display the following graphics as a minimum:

1. Home page to include a minimum of six critical points: Outside Air Temperature, Outside Air Relative Humidity, Enthalpy, KWH, KW, etc.
2. Graphic floor plans accurately depicting rooms, walls, hallways, and showing accurate locations of space sensors and major mechanical equipment.
3. Detailed graphics for each mechanical system including AHUs, ERUs, EFs, UVs, FCUs, heat exchangers, , as a minimum.
4. Access corresponding system drawings, technical literature, and sequences of operations directly from each system graphic.

F. The FMCS shall include individual graphical buttons to access the following data stored in PDF format:

1. Project control as-built documentation including all TCS drawings, diagrams and sequences of operation.
2. TCS Bill of Material for each system, e.g. AHU, RTU, FCU, boiler, etc.
3. Technical literature specification data sheets for all components listed in the TCS Bill of Material.

3.3 CONDUIT AND BOXES INSTALLATION

A. Conduit and Box Installation: Refer to Electrical Section 26 05 33 for execution and installation.

B. Conduit and Box Identification (color and labeling) installation. Refer to Electrical Section 26 05 53 for raceway and box identification installation.

C. Outlet Box Schedule: Thermostat/temperature sensor:

1. Dry Interior Locations: Provide 4" square galvanized steel with raised cover to fit flush with finished wall line. When located in concrete block walls, provide square edge title cover of sufficient depth to extend out to face of block or masonry boxes.
2. Other Conditions: Refer to Electrical Section 26 05 33 for requirements.

3.4 WIRE AND CABLE INSTALLATION

A. Wire and Cable Installation: Refer to Electrical Section 26 05 13 for execution and installation.

B. Field Quality Control:

1. Inspect wire and cable for physical damage and proper connection.
2. Torque test conductor connections and terminations to manufacturer's recommended values.
3. Perform continuity test on all conductors.
4. Protection of cable from foreign materials:

a. It is the Contractor's responsibility to provide adequate physical protection to prevent foreign material application or contact with any cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited, to overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid or compound that could come in contact with the cable, cable jacket or cable termination components.

b. Overspray of paint on any cable, cable jacket or cable termination component will not be accepted. It shall be the Contractor's responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed. This requirement is regardless of the PASS/FAIL test results of the cable containing overspray. Should the manufacturer and warrantor of the structured cabling system desire to physically inspect the installed condition and certify the validity of the structured cabling system (via a signed and dated statement by an authorized representative of the structured cabling manufacturer), the Owner may, at their sole discretion, agree to accept said warranty in lieu of having the affected cables replaced. In the case of plenum cabling, in addition to the statement from the manufacturer, the Contractor shall also present to the Owner a letter from the local Authority Having Jurisdiction stating that they consider the plenum rating of the cable to be intact and acceptable.

C. Installation Schedule:

1. Conduit terminations to all devices installed in applications with rotating equipment, expansion/contraction or vibration shall be made with flexible metallic conduit, unless noted otherwise. Final terminations to exterior devices installed in damp or wet locations shall be made with liquidtight flexible metallic conduit. Terminations in hazardous areas, as defined in the National Electrical Code, shall be made with flexible conduit rated for the environment.

3.5 FMCS INSTALLATION

A. Coordinate voltage and ampacity of all contacts, relays, and terminal connections of equipment being monitored or controlled. Voltage and ampacity shall be compatible with equipment voltage and be rated for full ampacity of wiring or overcurrent protection of circuit controlled.

B. Naming Conventions: Coordinate all point naming conventions with Owner standards. In the absence of Owner standards, naming conventions shall use equipment designations shown on plans.

3.6 PREPARATION FOR BALANCING

A. Verify that all dampers are in the position indicated by the controller (e.g., open, closed or modulating).

B. Check the calibration and setpoints of all controllers.

C. Check the locations of all thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts, or cold walls.

D. Check that all sequences operate as specified. Verify that no simultaneous heating and cooling occurs, unless specified. Observe that heating cannot begin at TAB reheat terminals until the unit is at the minimum cfm.

E. Verify the operation of all interlock systems.

3.7 TEST AND BALANCE COORDINATION

A. The Contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.

B. The Contractor shall provide a minimum of four (4) hours training for the Balancing Contractor in the use of these tools.

C. In addition, the Contractor shall provide a qualified technician to assist in the test and balance process until the first 20 terminal units are balanced.

D. The tools used during the test and balance process shall be returned at the completion of the testing and balancing.

3.8 DEMONSTRATION AND ACCEPTANCE

A. At completion of installation, provide two days minimum instruction for operators. Demonstrate operation of all controls and systems. Describe the normal operation of all equipment.

3.9 TRAINING

A. On-Site:

1. After completion of commissioning, the manufacturer shall provide 16 hours of training on consecutive days for 4 Owner's representatives. The training course shall enable the Owner's representatives to perform Day-to-Day Operations as defined herein. A factory-trained instructor with experience in presenting the training material and the system programmer for this project shall perform the training.

3.10 INSTALLATION OF SENSORS

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for the environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

D. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

E. Averaging sensors and low limits shall be installed at the top of the assembly with the element on a slight downward incline away from the sensor making a serpentine pattern over the cross-sectional area with elements spaced not over 12" apart and within 6" of the top and bottom of the area.

F. All pipe-mounted temperature sensors shall be installed in immersion wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.

G. Install outdoor air temperature sensors on exterior of north wall, complete with sun shield at designated location approved by Architect/Engineer. TCC shall prime and paint the device enclosure. Color selection by Architect.

H. Install all wall-mounted CO2 sensors between 3 feet and 6 feet above the floor.

3.11 INSTALLATION OF FLOW METERS

A. Provide manufacturer's recommended lengths of straight piping upstream and downstream of the flow meter. Up to 30 diameters upstream of the flow meter may be required depending on the piping arrangement and flow meter type.

B. Maintain adequate pull/service space.

END OF SECTION 23 09 00

SECTION 23 09 13 - INSTRUMENTATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pressure Gauge.

B. Pressure Gauge Accessories.

C. Thermometers.

D. Test Plugs.

E. Static and Differential Airflow Pressure Gauges.

PART 2 - PRODUCTS

2.1 PRESSURE GAUGES

A. Gauges shall be 4-1/2" diameter with aluminum or stainless steel case with phosphor bronze bourdon tube, brass socket for air, steam, water or oil application, 1/4" or 1/2" bottom connection. Gauges shall be 1% full scale accurate with bronze brushed brass movement and adjustable pointer. Standard ranges to be either pressure or pressure and vacuum as required of application.

B. Manufacturers:

1. Ashcroft
2. Marsh
3. Marshalltown
4. Miljoco
5. Trerice
6. U.S. Gauge Figure 1901
7. Weiss
8. Weksler
9. Wika.

C. Select gauge range for normal reading near center of gauge.

2.2 PRESSURE GAUGE ACCESSORIES

A. All pressure gauges shall have valves and pressure snubbers. All pressure gauges on steam shall have pigtail syphon.

B. Shutoff Valve: 1/4" ball valve as specified for each piping system.

C. Pressure snubber, brass with 1/4" connections, porous metal type.

2.3 THERMOMETERS

A. Dial Type:

1. 4-1/2" diameter, hermetically sealed case. Stainless steel case and stem. Accuracy of 1% full scale with external recalibrator.
2. Select thermometers for appropriate temperature range. Adjustable elbow joint with locking device to allow rotation of thermometer to any angle.
3. Stem lengths as required for application with minimum insertion of 2-1/2" .
4. Thermometers for water, steam, or oil shall have brass or steel separable socket. Thermometer wells shall be stainless steel, pressure rated to match piping system design pressure; with 2 inch extension for insulated piping and threaded cap nut with chain permanently fastened to well and cap. Thermometers for air shall have an aluminum or brass duct flange.
5. Manufacturer:

    a. Ashcroft
    b. Marsh
    c. Marshalltown
    d. Miljoco
    e. Tel-Tru
    f. Trerice
    g. U.S. Gauge
    h. Weiss
    i. Weksler, Wika.

B. Select scales to cover expected range of temperatures.

2.4 TEST PLUGS

A. Test Plug: 1/4" or 1/2" brass fitting and cap, with Nordel core for temperatures up to 275°F, for receiving 1/8" outside diameter pressure or temperature probe. Plugs shall be rated for zero leakage from vacuum to 500 psi.

B. Provide extended units for all plugs installed in insulated piping.

C. Test Kit: Carrying case, internally padded and fitted containing one 3-1/2" diameter pressure gauge with 0-100 psi range, one gauge adapter with 1/8" probes, two 1-1/2" dial thermometers with 0°° to 220°°F and -25°°F to 125°°F ranges and 5" stems.

1. Manufacturers:

    a. Sisco
    b. Flow Design
    c. Peterson Equipment
    d. MG Piping Products Co.
    e. Miljoco, Trerice
    f. Watts Regulator.

2.5 STATIC AND DIFFERENTIAL AIRFLOW PRESSURE GAUGES

A. Diaphragm-activated gauge with 4-3/4" dial, cast aluminum case, sealed interior, designed to resist shock and vibration, and rated for 15 psig .

B. Accuracy shall be ± 3% of full scale maximum throughout entire range at 70°F .

C. Provide mounting brackets, probes, and shutoff valves required for proper installation.

D. The range and service shall be as required for application or as noted on the drawings.

E. Manufacturers:

1. Dwyer Magnehelic Series 2000
2. Marshalltown Instrument Series 85C.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install per manufacturer's instructions.
2. Coil and conceal excess capillary on remote element instruments.
3. Install gauges and thermometers in locations where they are easily read from normal operating level.
4. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

B. Pressure Gauges:

1. Connect pressure gauges to suction and discharge side of all pumps.
2. Provide snubber for each pressure gauge.
3. Provide coil syphon for each pressure gauge connected to steam piping.

C. Thermometers:

1. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2" for installation of thermometer sockets.
2. Install thermometer sockets adjacent to control system thermostat, transmitter and sensor sockets.
3. Locate duct thermometers minimum 10 feet downstream of mixing dampers, coils, or other devices causing air turbulence.

END OF SECTION 23 09 13

SECTION 23 11 23 - NATURAL GAS PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe and Pipe Fittings.

B. Valves.

C. Natural Gas Piping System.

1.2 DELIVERY, STORAGE, AND HANDLING

A. Store and protect piping to prevent entrance of foreign matter into pipe and to prevent exterior corrosion.

B. Deliver and store valves in shipping containers with labeling in place.

1.3 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 22 05 00 for the required natural gas piping system electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

PART 2 - PRODUCTS

2.1 NATURAL GAS (0 TO 125 PSI)

A. Design Pressure: 125 psi.

1. Maximum Design Temperature: 350°F

B. Piping - 2" and Under:

1. Pipe: Standard weight steel, threaded and coupled, ASTM A53.
2. Joints: Screwed. (NOTE: For below ground, all sizes to have welded joints.)
3. Fittings: 150# steam - 300# CWP, black malleable iron, banded, ASTM A197, ANSI B16.3.
4. Unions: 250# - 500# CWP, black malleable iron, ANSI B16.39, ground joint with brass seat.

2.2 STRAINERS

A. Furnish pipe nipple with shutoff valve to blow down all strainer screens.

B. Use iron body strainers in ferrous piping.

2.3 DRAIN VALVES AND BLOWDOWN VALVES

A. Drain valve and blowdown valve shall mean a shutoff valve as specified for the intended service with added 3/4" male hose thread outlet, cap, and retaining chain.

PART 3 - EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends, remove burrs, bevel plain end ferrous pipe.

B. Remove scale and dirt on inside and outside before assembly.

C. Remove all scale, rust, dirt, oils, stickers and thoroughly clean exterior of all bare metal exposed piping, hangers, and accessories in preparation to be painted.

D. Connect to all equipment with flanges or unions.

E. After completion, fill, clean, and treat systems. Refer to Section 23 25 00 for treatment.

3.2 TESTING PIPING

A. Low Pressure - Up to 1 psi:

1. Test piping with 20 psi air pressure. System must hold this pressure without adding air for two hours.

B. High Pressure - Above 1 psi:

1. Test piping with compressed air at twice the operating gas pressure, but at least 20 psi. System must hold this pressure without adding air for two hours.

C. A non-combustible odorant, such as oil of wintergreen, may be added to help locate leaks.

3.3 CLEANING PIPING

A. Assembly:

1. Prior to assembly of pipe and piping components, remove all loose dirt, scale, oil and other foreign matter on internal or external surfaces by means consistent with good piping practice subject to approval of the Architect/Engineer. Blow chips and burrs out of pipe before assembly. Wipe cutting oil from internal and external surfaces.
2. During fabrication and assembly, remove slag and weld spatter from both internal and external joints by peening, chipping and wire brushing to the degree consistent with good piping practices.
3. Notify the Architect/Engineer prior to starting any post erection cleaning operation in time to allow witnessing the operation. Properly dispose of cleaning and flushing fluids.
4. Prior to blowing or flushing erected piping systems, disconnect all instrumentation and equipment, open wide all valves, control valves, and balance valves, and verify all strainer screens are in place.

3.4 INSTALLATION

A. Route piping in orderly manner, straight, plumb, with consistent pitch, parallel to building structure, with minimum use of offsets and couplings. Provide only offsets required for needed headroom or clearance and needed flexibility in pipe system.

B. Install piping to conserve building space, and not interfere with other work.

C. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment.

D. Group piping whenever practical at common elevations.

E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

F. Provide chain operators for all valves over 2" size that are over 10'-0" above finished floor. Extend to 7'-0" above finished floor.

G. Provide valve position indicator on all valves 10'-0" or greater above finish floor and not located above ceiling.

H. Provide clearance for access to valves and fittings.

I. Provide access doors where valves are not exposed.

J. Prepare pipe, fittings, supports, and accessories for finish painting.

K. Install valves with stems upright or horizontal, not inverted.

L. Arrange piping and piping connections so equipment may be serviced or totally removed without disturbing piping beyond final connections and associated shutoff valves.

M. Reducers are generally not shown. Where pipe sizes are not shown, the larger size in either direction shall continue through the fitting nearest to the indication of a smaller pipe size.

N. Install corrugated, stainless steel tubing system according to manufacturer's written instructions. Include striker plates to protect tubing from puncture where tubing is restrained and cannot move.

O. Establish minimum separation of one foot from other service's piping in accordance with CPC code.

3.5 BONDING AND GROUNDING

A. Each above ground portion of a corrugated stainless steel tubing gas piping systems shall be bonded to the electrical service grounding electrode system. The bonding jumper shall connect to a metallic pipe or fitting between the point of delivery and the first downstream corrugated stainless steel tube fitting. The bonding jumper shall not be smaller than 6 AWG copper wire or equivalent. Gas piping systems that contain one or more segments of corrugated stainless steel tubing shall be bonded in accordance with this section.

B. Each above ground portion of a gas piping system, other than corrugated stainless steel tubing systems, that is likely to become energized shall be electrically continuous and bonded to an effective ground-fault current path. Gas piping, other than corrugated stainless steel tubing, shall be considered to be bonded when it is connected to appliances that are connected to the appliance grounding conductor of the circuit supplying that appliance.

C. Gas piping shall not be used as a grounding conductor or electrode.

D. Where a lightning protection system is installed, the bonding of the gas piping shall be in accordance with NFPA 780, Standard for the Installation of Lightning Protection Systems.

3.6 PIPE ERECTION AND LAYING

A. Carefully inspect all pipe, fittings, valves, equipment and accessories prior to installation. Immediately reject and remove from the job any items which are unsuitable, cracked or otherwise defective.

B. All pipe, fittings, valves, equipment and accessories shall have factory-applied markings, stampings, or nameplates sufficient to determine their conformance with specified requirements.

C. Exercise care at every stage of storage, handling, laying and erecting to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not erect or install any unclean item.

D. During construction, until system is fully operational, keep all openings in piping and equipment closed at all times except when actual work is being performed on that item. Closures shall be plugs, caps, blind flanges or other items designed for this purpose.

E. Change direction of pipes only with fittings or pipe bends. Change size only with fittings. Do not use miter fittings, face or flush bushings, or street elbows. All fittings shall be long radius type, unless otherwise shown on the drawings or specified. Construct welded elbows of angles not available as standard fittings by cutting and welding standard elbows to form smooth, long radius fittings.

F. Use full and double lengths of pipe wherever possible.

G. Cut all pipe to exact measurement and install without springing or forcing.

H. Do not create, even temporarily, undue loads, forces or strains on valves, equipment or building elements.

3.7 DRAINING AND VENTING

A. Unless otherwise indicated on the drawings, all horizontal pipes, including branches, shall pitch 1" in 40 feet to low points for complete drainage.

B. Use eccentric reducing fittings on horizontal runs when changing size for proper drainage and venting. Install gas pipes with bottom of pipe and eccentric reducers in a continuous line.

C. Provide drip legs at low points and at the base of all risers in gas pipes. Drip legs shall be full line size on pipes through 4" and at least 4", but not less than half line size over 4". Drip legs shall be 12" minimum length, capped with a reducer to a drain valve.

3.8 BRANCH CONNECTIONS

A. Make branch connections with standard tee or cross fittings of the type required for the service unless otherwise specified herein or detailed on the drawings.

B. At the option of the Contractor, branch connections from headers and mains may be cut into black steel pipe using forged weld-on fittings.

C. Use of forged weld-on fittings is also limited as follows:

1. Must have at least same pressure rating as the main.
2. Header or main must be 2-1/2" or over.
3. Branch line is at least two pipe sizes under header or main size.

D. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it.

E. All branch piping connections for natural gas shall take off on the top or on the side of the main.

3.9 JOINING OF PIPE

A. Threaded Joints:

1. Ream pipe ends and remove all burrs and chips.
2. Protect plated pipe and valve bodies from wrench marks when making up joints.
3. Apply Teflon tape to male threads.

3.10 PAINTING EXPOSED PIPE

A. Paint all outdoor exposed natural gas piping the color selected by Owner or Architect/Engineer.

3.11 SERVICE CONNECTIONS

A. Provide new gas service complete with gas meter and regulators. Verify gas service pressure with the Utility Company.

END OF SECTION 23 11 23

SECTION 23 21 00 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe and Pipe Fittings

B. Valves

C. Check Valves

D. Strainers

E. System Piping Schedule

1.2 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body. Remanufactured valves are not acceptable.

B. Welding Materials, Procedures, and Operators: Conform to ASME Section 9, ANSI/AWS D1.1, and applicable state labor regulations.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Store and protect piping to prevent entrance of foreign matter into pipe and to prevent exterior corrosion.

B. Deliver and store valves in shipping containers with labeling in place.

1.4 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 23 05 00 for required hydronic systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

PART 2 - PRODUCTS

2.1 STEEL PIPE (ABOVE GRADE) 4" and larger

A. Design Pressure 125 psig, Maximum Design Temperature 225°F (230°F for grooved couplings).

B. Black Steel; Standard Weight; Mechanically Coupled Grooved Joints:

1. Pipe: Standard weight black steel, grooved ends, ASTM A53, Type E or S, Grade B.

2. Joints: Grooved type, with Grade E EPDM molded pressure-responsive gaskets suited for 32°F to 230°F per ASTM D2000.

    a. Rigid Type: Housings cast with offsetting, angle-pattern, bolt pads to provide system rigidity and support. Design Basis: Victaulic 107N.

        1) Usage: All locations unless noted elsewhere.

    b. Flexible Type: Housing cast with horizontal, angle-pattern bolt pads to provide vibration attenuation and stress relief.Design Basis: Victaulic 177N.

        1) Usage: first three joints adjacent to vibrating equipment (e.g., chillers, pumps, air handling equipment, etc.).

3. Fittings: ASTM A536 Grade 65-45-12 ductile or A47 malleable iron, grooved type.
4. Flanges: Grooved end, flanged adapter.

2.2 COPPER PIPE (ABOVE GRADE) 3" and smaller

A. Design Pressure 125 psig. Maximum Design Temperature 225°F.

B. Copper Pipe; Type L; Soldered Joints:

1. Tubing: Type L drawn temper seamless copper tube, ASTM B88.
2. Joints: Solder with Type 95-5 solder. 50-50 solder is not acceptable.
3. Fittings: Wrought copper solder joint, ASME B16.22.

C. Copper Pipe; Type L; Mechanical Press Connection:

1. Tubing: Type L hard drawn seamless copper tube, ASTM B88.
2. Joints: Mechanical press connection.
3. Fittings: Copper, ANSI B-16.22, with embedded EPDM O-ring, NSF-61.
4. Manufacturers:

    a. Viega ProPress.
    b. Elkhart Xpress.
    c. NIBCO Press System Fittings and Valves.
    d. Mueller Streamline PRS.

D. Copper; DWV; Soldered:

1. Tubing: DWV drawn temper seamless copper drainage tube, ASTM B306.
2. Joints: Solder with Type 95-5 solder. 50-50 solder is not acceptable.
3. Fittings: ASME B16.23 cast brass, or ASME B16.29 solder wrought copper.

2.3 VALVES

A. Shutoff Valves:

1. For pipe systems where mechanical press connections are allowed, shutoff valves with mechanical press connections are acceptable subject to the requirements in the paragraphs below.
2. Ball Valves:

    a. BA-1 (Steel and Copper): 3" and under, 125 psi saturated steam, 600 psi WOG, full port, screwed or solder ends (acceptable only if rated for soldering in line with 470°°F melting point of lead-free solder), bronze body of a copper alloy containing less than 15% zinc, stainless steel ball and trim, Teflon seats and seals.

        1) Manufacturers:

            a) Apollo #77C-140
            b) Stockham #S-206 BR1-R
            c) Milwaukee #BA-400
            d) Watts
            e) Nibco #585-70-66
            f) National Utilities Co.
            g) RUB.

        2) Provide extended shaft with operating handle of non-thermal conductive material and protective sleeve that allows operation of valve, adjustment of the packing, and adjustment of the memory stop without breaking the vapor seal or disturbing the insulation for all valves in insulated piping.
        3) Provide lock out trim for all valves opening to atmosphere installed in domestic water piping over 120°°F, heating water piping over 120°°F, steam, condensate, boiler feed water piping, compressed air piping and gasoline/kerosene piping, and as indicated on the drawings. Solid extended shaft is not required on valves with lock out trim.

    b. BA-1A (Steel): 2-1/2" and 3", 125 psi saturated steam, 275 psi WOG ANSI Class, 150 psi standard port, carbon steel body stainless steel ball and trim, Teflon seats and seals.

        1) Manufacturers:

            a) Apollo #88A-100
            b) Nibco #F510-CS/66
            c) Milwaukee #F90.

        2) Provide extended shaft with operating handle of non-thermal conductive material and protective sleeve that allows operation of valve, adjustment of the packing, and adjustment of the memory stop without breaking the vapor seal or disturbing the insulation for all valves in insulated piping.
        3) Provide lock out trim for all valves opening to atmosphere installed in domestic water piping over 120°°F, heating water piping over 120°°F, steam, condensate, boiler feed water piping, compressed air piping and gasoline/kerosene piping, and as indicated on the drawings. Solid extended shaft is not required on valves with lock out trim.

3. Butterfly Valves:

a. BF-1:

1) 2-1/2" thru 6", 175 psi CWP, elastomers rated for 20°°F to 225°°F continuous and 250°°F intermittent at 125 psig, fully lugged end, ductile or cast iron body (not in contact with fluid); bronze, aluminum-bronze or EPDM coated ductile iron disc; EPDM seat, stainless steel stem, extended neck, 175 psi bubble-tight, bi-directional dead-end shutoff without backing flange or nuts and with cap screws extending to centerline of valve body (for pipe extension without draining system), 10 position locking operator up to 6" size. Cv of at least 1580 in 6" size.

2) Manufacturers:

a) Center Line Series 200
b) Keystone #222
c) Watts #DBF-03-121-1P
d) Nibco N200 Series or LD2000 Series
e) Milwaukee CL series
f) Hammond 5200 series.

3) 8" thru 12", 175 psi CWP, elastomers for 20°°F to 225°°F at 130 psi, fully lugged end, ductile or cast iron body (not in contact with fluid), bronze, EPDM coated ductile iron or aluminum-bronze disc, EPDM seat, stainless steel stem, extended neck, 175 psi bubble-tight, bi-directional dead-end shutoff without backing flange or nuts and with cap screws extending to the centerline of the valve body (to permit pipe extension without draining system), weatherproof gear operator.

4) Manufacturers:

a) Center Line Series 225
b) Watts #DBF-03-121-1G
c) Nibco N200 Series or LD2000 Series
d) Milwaukee CL series, Hammond 5200 series.

5) Mechanically coupled grooved end valves are acceptable if they have the temperature ratings, pressure ratings, and features listed above.

6) Manufacturers:

a) Victaulic #300
b) Nibco GD4765.

## 2.4 THROTTLING VALVES

A. Throttling Valves (Steel):

1. For pipe systems where mechanical press connections are allowed, throttling valves with mechanical press connections are acceptable subject to the requirements in the paragraphs below.
2. Globe Valves (Steel Pipe):

a. GL-1: 3" and under, 125 psi saturated steam, 300 psi WOG, screwed, bronze.

1) Manufacturers:

a) Crane #7TF
b) Stockham #B22T
c) Walworth #95
d) Milwaukee #590
e) Hammond #IB413T
f) Watts #B-4010-T
g) or NIBCO #T-235.

b. GL-2: 4" thru 10", 125 psi S @ 353°°F, 200 psi WOG @ 150°°F, flanged, iron body, bronze mounted.

1) Manufacturers:

a) Crane #351
b) Hammond #IR116
c) Stockham #G-512
d) Walworth #906F
e) Milwaukee #F2981
f) Watts #F-501
g) or NIBCO #F-718.

3. Globe Valves (Copper Pipe):

a. GL-5: 2" and under, 125 psi saturated steam, 300 psi WOG, solder, bronze.

1) Manufacturers:

a) Hammond #IB423
b) Stockham #B24T
c) Milwaukee #1590
d) Watts #B-4011-T
e) NIBCO #S-235.

4. Ball Valves (Steel and/or Copper):

a. BA-9: 2" and under, 125 psi saturated steam, 600 psi WOG, standard port, screwed (solder ends are acceptable only if rated for soldering in line with 470°°F melting point of lead-free solder), bronze body and ball of copper alloy containing less than 15% zinc, chrome plated or stainless steel ball, Teflon seats and seals with memory stop.

1) Manufacturers:

a) Apollo #70-120
b) Stockham #S-216BR-R
c) Milwaukee #BA-100
d) Watts #B-6000
e) Hammond #8501
f) Nibco #580-70.

5. Butterfly Valves:

a. BF-4:

1) 2-1/2" thru 6", 175 psi CWP, elastomers rated for 20°°F to 225°°F continuous and 250°°F intermittent at 125 psig, fully lugged or grooved end, ductile or cast iron body (not in contact with fluid); bronze, aluminum-bronze or EPDM coated ductile iron disc; EPDM seat, stainless steel stem, extended neck, 175 psi bubble-tight, bi-directional dead-end shutoff without backing flange or nuts and with cap screws extending to centerline of valve body (for pipe extension without draining system), infinite position locking operator with memory stop up to 6" size. Cv of at least 1580 in 6" size.

2) Manufacturers:

a) Victaulic #300
b) Center Line Series 200
c) Keystone #222
d) Watts #DBF-03-121-1P
e) NIBCO LD2000 Series
f) Milwaukee CL series
g) Hammond 5200 series.

2.5 LOCK OUT TRIM

A. Provide lock out trim for all quarter turn valves opening to atmosphere installed in heating water piping over 120°°F and as indicated on the drawings.

2.6 CHECK VALVES

A. For pipe systems where mechanical press connections are allowed, check valves with mechanical press connections are acceptable subject to the requirements in the paragraphs below.

B. CK-1: Check Valves (Steel Pipe); 2" and under, 125 psi S @ 353°F, 200 psi WOG @ 150°F, screwed, bronze, horizontal swing.

1. Manufacturers:

a. Crane #37
b. Hammond #IB904
c. Stockham #B319
d. Walworth #406
e. Milwaukee #509
f. Watts #B-5000
g. or NIBCO #T-413.

C. CK-13: Check Valves (Steel Pipe); 2-1/2" thru 12", 200# WOG, double disc wafer type, iron body, bronze or aluminum-bronze discs, 316SS shaft and spring, Viton, EPDM or BUNA-N, Cv of at least 700 in 6" size.

1. Manufacturers:

a. Mueller Steam Specialty Co. #71-AHB-6-H
b. Stockham #WG-961
c. NIBCO W-920-W
d. Crane
e. Victaulic #716/716H/779.

D. CK-4: Check Valves (Copper Pipe); 2" and under, 200 psi WOG @ 150°°F, solder, bronze, horizontal swing.

1. Manufacturers:

a. Crane #1342
b. Hammond #IB912
c. Stockham #B309
d. Walworth #406SJ
e. Milwaukee #1509
f. Watts #B-5001
g. NIBCO #S-413.

2.7 STRAINERS

A. For pipe systems where mechanical press connections are allowed, strainers with mechanical press connections are acceptable subject to the requirements in the paragraphs below.

B. ST-1: Bronze body, screwed ends, screwed cover, 125 psi S @ 353°F, 200 psi WOG @ 150°F.

1. Manufacturers:

a. Armstrong #F4SC
b. Metraflex #TS
c. Mueller Steam Specialty Co. #351
d. Sarco #BT
e. Watts #777
f. NIBCO T-122-A.

C. ST-2: Cast iron body, 125 lb. flanged ends, bolted cover, 125 psi S @ 353°F, 175 psi WOG @ 150°F.

1. Manufacturers:

a. Armstrong #A1FL
b. Metraflex #TF
c. Mueller Steam Specialty Co.#758
d. Sarco #CI-125
e. Watts #77F-D
f. Victaulic #732 or #W732
g. NIBCO F-721-A.

D. Unless otherwise indicated, strainers shall be Y-pattern and have stainless steel screens with perforations as follows

1. Pipe Size:

    a. 1/4" - 2": 1/32" screen
    b. 2-1/2" - 8": 1/16" screen

E. Furnish pipe nipple with ball valve, threaded hose connection, and cap to blow down all strainer screens.

F. Use bronze body strainers in copper piping and iron body strainers in ferrous piping.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Ream pipe and tube ends, remove burrs, bevel plain end ferrous pipe.

B. Remove scale and dirt on inside and outside before assembly.

C. Remove all scale, rust, dirt, oils, stickers and thoroughly clean exterior of all bare metal exposed piping, hangers, and accessories in preparation to be painted.

D. Connect to all equipment with flanges or unions.

E. After completion, fill, clean, and treat systems. Refer to Section 23 25 00 for treatment.

### 3.2 SYSTEMS, PIPING, AND VALVE SCHEDULE

A. Heating Water (Above Grade - maximum 140°F):

1. Copper Pipe; Type L; Soldered Joints: 3" and Under
2. Black Steel; Standard Weight; Grooved Joints: 4:and Over
3. Copper Pipe; Type L; Mechanical Press Connection: " and Under
4. Shutoff Valves: GA-1, BA-1, BF-1, BF-5
5. Throttling Valves: GL-1, GL-2
6. Check Valves: CK-4, CK-13
7. Strainers: ST-1, ST-2

### 3.3 TESTING PIPING

A. Test pipes underground or in chases and walls before piping is concealed.

B. Complete testing before insulation is applied. If insulation is applied before pipe is tested and a leak ruins the insulation, replace all damaged insulation.

C. Test the pipe with water at 1.5 times the design pressure but not less than 100 psig pressure. Hold pressure for at least two hours.

D. Test to be witnessed by the Architect/Engineer or their representative, if requested by the Architect/Engineer.

## 3.4 CLEANING PIPING

A. Assembly:

1. Prior to assembly of pipe and piping components, remove all loose dirt, scale, oil and other foreign matter on internal or external surfaces by means consistent with good piping practice subject to approval of the Architect/Engineer. Blow chips and burrs out of pipe before assembly. Wipe cutting oil from internal and external surfaces.
2. During fabrication and assembly, remove slag and weld spatter from both internal and external joints by peening, chipping and wire brushing to the degree consistent with good piping practices.
3. Notify the Architect/Engineer prior to starting any post erection cleaning operation in time to allow witnessing the operation. Properly dispose of cleaning and flushing fluids.
4. Prior to blowing or flushing erected piping systems, disconnect all instrumentation and equipment, open wide all valves, control valves, and balance valves, and verify all strainer screens are in place.

B. Chemical Cleaning:

1. Flush pipe and components with clean water until all discharge from system is clean. Maintain minimum velocities at all points of 5 feet/second for 30 minutes. Flow shall be in same direction as when system is in normal operation. Discharge shall be from low points of pipes, ends of headers and as otherwise needed to flush entire system. After flushing, all residual water shall be drained and/or blown out.
2. Add 2 pounds of trisodium phosphate per 100 gallons of system capacity. Use an alternate chemical if discharge of trisodium phosphate is not permitted. Maintain 150°F in the system if possible. If heat is not available, use 3 pounds per 100 gallons.
3. Drain the system after circulating the chemical cleaner for six hours at 150°F, or 12 hours at a lower temperature. Refill. Test a water sample. Drain and fill again if excessive cleaning chemicals remain and until water appears clear.
4. After each system has been cleaned and thoroughly flushed of pretreatment chemicals, it shall be immediately refilled with water and treated with chemical treatment as specified in Section 23 25 00. The system shall not be allowed to sit empty for any length of time.
5. When system water is clear, remove, clean and replace all strainers.
6. Water samples may be taken by the Architect/Engineer to verify a clean system. If system is not clean, the entire process, including chemical treatment specified in Section 23 25 00, shall be repeated at the Contractor's expense.
7. Chemical cleaning applies to the following systems:

    a. Heating Water

## 3.5 INSTALLATION

A. General Installation Requirements:

1. Route piping in orderly manner, straight, plumb, with consistent pitch, parallel to building structure, with minimum use of offsets and couplings. Provide only offsets required for needed headroom or clearance and needed flexibility in pipe system.
2. Install piping to conserve building space, and not interfere with other work.
3. Group piping whenever practical at common elevations.

4. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
5. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it. Where pipe sizes are not shown, the larger size in either direction shall continue through the fitting nearest to the indication of a smaller pipe size.
6. Install bell and spigot pipe with bells upstream.
7. Seal pipes passing through exterior walls with a wall seal per Section 23 05 29. Provide Schedule 40 galvanized sleeve at least 2 pipe sizes larger than the pipe.
8. Branch takeoffs shall be from the top side (if branch is two sizes smaller than main), or any angle from the horizontal plane to the top of piping.

B. Installation Requirements in Electrical Rooms:

1. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment plus its required clearance space.

3.6 PIPE ERECTION AND LAYING

A. Carefully inspect all pipe, fittings, valves, equipment and accessories prior to installation. Immediately reject and remove from the job any items which are unsuitable, cracked or otherwise defective.

B. All pipe, fittings, valves, equipment and accessories shall have factory-applied markings, stampings, or nameplates sufficient to determine their conformance with specified requirements.

C. Exercise care at every stage of storage, handling, laying and erecting to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not erect or install any unclean item.

D. During construction, until system is fully operational, keep all openings in piping and equipment closed at all times except when actual work is being performed on that item. Closures shall be plugs, caps, blind flanges or other items designed for this purpose.

E. Change direction of pipes only with fittings or pipe bends. Change size only with fittings. Do not use miter fittings, face or flush bushings, or street elbows. 2-1/2" and larger fittings shall be long radius type, unless otherwise shown on the drawings or specified. Construct welded elbows of angles not available as standard fittings by cutting and welding standard elbows to form smooth, long radius fittings.

F. Use full and double lengths of pipe wherever possible.

G. Unless otherwise indicated, install all inlet and outlet piping, including shutoff valves and strainers, to coils, pumps and other equipment at line size with reduction in size being made only at control valve or pump.

H. Cut all pipe to exact measurement and install without springing or forcing except in the case of expansion loops where cold springing is indicated on the drawings.

I. Do not create, even temporarily, undue loads, forces or strains on valves, equipment or building elements.

3.7 DRAINING AND VENTING

A. Unless otherwise indicated on the drawings, all horizontal pipes, including branches, shall pitch 1" in 40 feet to low points for complete drainage, removal of condensate, and venting.

B. Provide drain valves at all low points of water piping systems or where indicated on drawings for complete or sectionalized draining. Drain valves are defined above.

C. Use eccentric reducing fittings on horizontal runs when changing size for proper drainage and venting. Install all liquid lines with top of pipe and eccentric reducers in a continuous line.

D. Provide air vents at all high points and wherever else required for elimination of air in all water piping systems. Do not use automatic air vents in glycol systems unless they are piped to the fill tank.

E. Air vents shall be in accessible locations. If needed to trap and vent air in a remote location, a 1/8" pipe shall connect the tapping location to a venting device in an accessible location.

F. All vent and drain piping shall be of same materials and construction as the service involved.

3.8 BRANCH CONNECTIONS

A. Make branch connections with standard tee or cross fittings of the type required for the service unless otherwise specified herein or detailed on the drawings.

B. At the option of the Contractor, branch connections from headers and mains may be cut into black steel pipe using forged weld-on fittings.

3.9 JOINING OF PIPE

A. Solder Joints (Copper Pipe):

1. Make up joints with 95% tin and 5% antimony (95-5) solder conforming to ASTM B32 Grade 95TA. Cut copper tubing ends perfectly square and remove all burrs inside and outside. Thoroughly clean sockets of fittings and ends of tubing to remove all oxide, dirt and grease just prior to soldering. Apply flux evenly, but sparingly, to all surfaces to be joined. Heat joints uniformly to proper soldering temperature so solder flows to all mated surfaces. Wipe excess solder, leaving a uniform fillet around cup of fitting.
2. Flux shall be non-acid type conforming to ASTM B813.
3. Solder end valves may be installed directly in the piping system if the entire valve is suitable for use with 470°F melting point solder. Remove composition discs and all seals during soldering if not suitable for 470°F.

B. Mechanically Coupled Grooved Joints (Steel):

1. Grooved connections shall mechanically engage, lock and seal the grooved pipe ends in a positive couple. Each coupling shall have malleable iron housing clamps, steel bolts and nuts, and sealing gasket designed so internal pressure increases the tightness of the seal. Couplings must be installation-ready style for quick installation and no more than two-piece housings.
2. All work, including pipe grooving, shall be accomplished in accordance with manufacturer's published instructions.
3. Final tightening of bolts shall be with a torque wrench to ensure equal tension in all bolts.
4. All fittings shall be provided by one manufacturer. Mixing grooved components is not acceptable.
5. Product Warranty:

    a. Standard: One-year product warranty. A factory-trained manufacturer's representative shall visit the site for contractor training and installation observation.

        1) On-site Training: Manufacturer's factory trained representative shall provide training of contractor's field personnel in use of grooving tools and installation of product. Documentation of installing contractor training with manufacturer's representative shall be submitted to the Architect/Engineer.
        2) Job Site Visitation: Manufacturer's representative shall periodically visit job site to ensure manufacturer’s installation practices are being followed.

6. Acceptable Manufacturers: Victaulic, Gruvlok, or Star Fittings.

C. Mechanical Press Connection (Copper):

1. Copper press fitting shall be made in accordance with the manufacturer’s installation instructions.
2. Fully insert tubing into the fitting and mark tubing.
3. Prior to making connection, the fitting alignment shall be checked against the mark made on the tube to ensure the tubing is fully engaged in the fitting.
4. Joint shall be pressed with a tool approved by the manufacturer. Installers shall be trained by manufacturer personnel or representative. Provide documentation upon request.

END OF SECTION 23 21 00

SECTION 23 21 16 - HYDRONIC SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Air Vents

B. Basket Strainers

C. Makeup Water Accessories

D. Safety Relief Valves

E. Suction Diffusers

F. Balancing Valves

G. Combination Piping Packages

H. Expansion Tank

I. Sidestream Filters

J. Drain Valves and Blowdown Valves

1.2 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body. Remanufactured valves are not acceptable.

B. Welding Materials, Procedures, and Operators: Conform to ASME Section 9, ANSI/AWS D1.1, and applicable state labor regulations.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 23 05 00. Include data on pipe materials, fittings, valves, and accessories. Include manufacturers' support spacing requirements for plastic piping.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store and protect piping to prevent entrance of foreign matter into pipe and to prevent exterior corrosion.

B. Deliver and store valves in shipping containers with labeling in place.

1.5 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 23 05 00 for required hydronic systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

PART 2 - PRODUCTS

2.1 AIR VENTS

A. At end of main and other points where large volume of air may be trapped, use 1/4" globe valve, angle type, 125 psi, Crane #89, attached to coupling in top of main, 1/4" discharge pipe turned down with cap.

B. On branch lines and small heating units, use coin-operated air vent equal to B&G #4V, attached to 1/8" coupling in top of pipe. Install air vents on all coils and terminal heating units.

2.2 AUTOMATIC AIR VENTS (only where specifically noted on drawings)

A. Low capacity automatic air vent (for bladder tank anti-thermosyphon loops). Maximum operating pressure and temperature of at least 240°F and 125 psi, 1/2" or 3/4" inlet.

1. Manufacturers:

a. B&G #87
b. Armstrong
c. Spirotherm
d. Taco
e. Watts

2.3 BASKET STRAINERS

A. Cast iron body, 125 lb. flanged ends, quick release bolted, rated for 125 psi @ 350°F, 175 psi WOG @ 150°F. Strainer to have 1/8" perforated basket or equivalent. Pressure drop not to exceed 5 ft. head maximum.

B. Basket strainer shall be supported from floor. Hanging strainer from pipes will NOT be acceptable.

C. Furnish pipe nipple with ball valve, threaded hose connection, and cap to blow down all strainer screens.

D. Furnish hinged cover for strainers below 6" in size. Furnish lifting lug and lifting device to remove cover of strainers 8" and larger. Provide O-ring gaskets on all covers.

E. Furnish ASTM stamped 126-B or A216 grade WCB.

F. Manufacturers:

1. Keckley GFV

2. Mueller 125F-CI
3. SureFlow BFC 125C
4. Watts 97FB-CIB
5. Metraflex B-1-TC

2.4 MAKEUP WATER ACCESSORIES

A. Pressure Reducing Valve:

1. For water fill lines to hydronic systems.
2. Removable strainer, field adjustable discharge pressure, brass body, disc and seat, union with 1/2" or 3/4" NPT sweat connection, 125 psig maximum working pressure, 225°F maximum temperature.
3. Manufacturers:

a. Armstrong
b. Bell & Gossett
c. Conbraco
d. Thrush
e. Watts

B. Relief Valve:

1. For water fill lines to hydronic systems.
2. Manufacturers:

a. Armstrong
b. Bell & Gossett
c. Conbraco
d. Taco
e. Watts

C. Backflow Preventer:

1. Reduced pressure type as scheduled on the drawings.
2. Provide an air gap fitting and piping to drain.
3. If not indicated on the drawings, unit shall be same size as pipe.
4. Field test and tag units per manufacturer's instructions by a certified tester before initial operation.

2.5 SAFETY RELIEF VALVES

A. SRV-1 (Hydronic Heating Systems): Spring-loaded disc type with cast iron or bronze body, bronze or stainless steel disc, side outlet and lifting lever for maximum service of 125 psig at 250°F. For relieving water during pressure fluctuations and in case of control failure. Capacities shall be ASME Section IV certified and labeled.

B. Manufacturers:

1. Kunkle # 537
2. B&G

3. Conbraco
4. McDonnell & Miller
5. Watts

2.6 SUCTION DIFFUSER

A. Furnish and install on base-mounted pumps with inlet size same as pipe size shown on the drawing.

B. In no case shall pressure drop exceed 3.0 psi.

C. Suction diffuser shall consist of angle body with inlet vanes and combination diffuser-strainer-orifice cylinder with 3/16" diameter openings for pump protection, gauge tappings, and blowdown connection. Orifice cylinder, with bronze or stainless steel strainer with free area at least 5 times cross section area of pump suction opening. Furnish adjustable foot to support weight of suction piping. Connect drain valve to blowdown connection. Provide 16 mesh bronze startup strainer. The startup strainer shall be removed after the system has been started, cleaned, and is operating under normal conditions, but before the system is turned over to the Owner. Hang the startup strainer on the piping near the pump after it is removed.

D. Manufacturers:

1. Amtrol
2. Armstrong
3. Bell & Gossett
4. Patterson
5. Taco
6. Wheatley
7. Victaulic

2.7 BALANCING VALVE

A. Rated for 125 psi working pressure and 250°F operating temperature, taps for determining flow with a portable meter, positive shutoff valves for each meter connection, memory feature, tight shutoff, and a permanent pressure drop between 1' and 2' water column at full flow with valve 100% open. Furnish with molded, removable insulation covers.

B. Provide a nomograph to determine flow from meter reading (and valve position on units that sense pressure across a valve). Graph shall extend below the specified minimum flow.

C. Furnish one meter kit equivalent to Bell & Gossett Model RO-5 meeting the following requirements:

1. Carrying case with handle.
2. Pressure gauge with 0-25 feet of head scale with 3.0% full scale accuracy.
3. High and low side hoses with 5 feet length and 250 psig pressure rating, equipped with shutoff valves, vent valves, and probes for insertion into pressure and temperature plugs.

D. Valves in copper piping shall be brass or bronze.

1. Multi-Turn Style (Brass or Bronze):

a. Manufacturers:

1) Tour&Anderson (STAD)
2) Armstrong "CBV"
3) Victaulic 786
4) Macon STVL/STV
5) MEPCO MBV
6) Wheatly GS
7) NIBCO 1710

E. Valves in ferrous piping 2" or smaller shall have threaded ends and steel, brass or bronze construction. Option to balancing valves noted above are flow sensors specified in Section 23 09 00 with a specified throttling valve.

1. Multi-Turn Style (Ferrous Piping ä? 2"):

a. Manufacturers:

1) TA Hydronics "786-789"
2) Armstrong "CBV"
3) Victaulic 787
4) Macon STVL/STV
5) MEPCO MBV
6) Wheatly GSNIBCO 1710 (T1710L)

F. Balancing valves in ferrous piping over 2 size shall have flanged or grooved ends and steel or cast iron construction. Option to balancing valves noted above are flow sensor specified in Section 23 09 00 with a specified throttling valve.

1. Multi-Turn Style (Ferrous Piping Greater Than 2"):

a. Manufacturers:

1) Armstrong "CVB-II"
2) Tour&Anderson (STAF, STAG)
3) Victaulic 788/789
4) Macon STVA
5) MEPCO MBV
6) NIBCO 737

G. Manufacturer shall size balancing valves for the scheduled flow rate. Flow rate shall be measurable on manufacturer's standard meters.

2.8 COMBINATION PIPING PACKAGES

A. Combination piping packages are allowed at unitary equipment only (1” pipe size and smaller) in lieu of individual components specified for hydronic coils and devices containing hydronic coils. Configuration of combination pieces shall match layouts on the drawings. Each component of the combination piping packages shall meet these specifications for the individual components being combined. Coil connections shall be rigid. Combination piping packages shall include:

1. Shutoff valves
2. Wye strainers , with 1/4 turn strainer blowdown valves with hose thread and cap
3. Manual balancing valves with memory stop. Automatic flow control devices are not allowed.
4. Test plugs
5. Manual air vents
6. Unions

B. Manufacturers:

1. FDI Flowset
2. Griswold
3. Hays Fluid Controls
4. HCI Terminator
5. Nexus Coil Pak
6. NIBCO, Victaulic

2.9 EXPANSION TANK

A. Bladder Type:

1. Tank shall be welded steel, ASME construction and stamped.
2. Tank shall be complete with heavy-duty replaceable butyl bladder, charging valve, lifting ring, drain tapping, and system connection.
3. 125 psig working pressure and 240°F maximum operating temperature.
4. Manufacturers:

a. Thrush
b. Taco
c. Bell & Gossett
d. Armstrong
e. Watts
f. Wessels
g. Wheatley
h. Amtrol
i. Patterson
j. Grundfos

2.10 COALESCING TYPE COMBINATION AIR ELIMINATOR AND DIRT SEPARATOR

A. Coalescing type air eliminator and dirt separator shall be fabricated from steel and ASME constructed and certified for 125 psi working pressure rated for 150 psig working pressure. Designed and constructed in accordance with ASME with ASME stamp, with two equal chambers above and below the inlet / outlet nozzles. Flanges to be Class 150, raised face, weld neck. and 270°F operating temperature. Units 2-1/2 inches and smaller shall have threaded connections. Units 3 inches and larger shall have flanged connections.

B. Unit shall include internally structured coalescing media elements uniformly filling the entire vessel to suppress turbulence and provide air elimination efficiency of less than 99.5% free and entrained air, and 99.6% dissolved air at the installed location. Dirt separation efficiency shall be a minimum of 80% of all particles 30 micron and larger within 100 passes. Units capable of 5 micron dirt removal.

C. Air elimination and dirt separation shall be by coalescing action by copper tubes with continuous wound, permanently attached copper wire and followed by a separate continuous wound permanently affixed copper wire.

D. Provide unit with factory mounted air vent at the top of the air elimination chamber.

E. Provide brass flushing cock on the separator side to facilitate system fast-fill and to blow down impurities from the water surface within the separator.

F. Provide factory-mounted blowdown valve on the unit bottom to allow for draining and cleaning. Coalescing separators shall be equipped with removable cover to allow for removal, inspection. and cleaning of the internal coalescing media. Unit shall be manufactured with a removable lower head for internal inspection.

G. Units shall be painted. Units with a primer finish are not acceptable.

H. Warranty: Three-year.

I. Coalescing separator shall be as sized on the construction drawings, but in no case shall it have less than line size connections nor shall entering velocity exceed 10 feet per second. Pressure drop shall not exceed 5psi at design flow. Include on submittal the pressure drop of each unit at its design flow rate.

J. Manufacturers:

1. Spirotherm
2. Wessels WVA
3. Thrush

2.11 DRAIN VALVES AND BLOWDOWN VALVES

A. Drain valve and blowdown valve shall mean a shutoff valve as specified for the intended service with added 3/4" male hose thread outlet, cap, and retaining chain.

2.12 CONNECTIONS BETWEEN DISSIMILAR METALS

A. Connections between dissimilar metals shall be insulating dielectric types that provide a water gap between the connected metals, and that either allow no metal path for electron transfer or that provide a wide water gap lined with a non-conductive material to impede electron transfer through the water path.

B. Joints shall be rated for the temperature, pressure, and other characteristics of the service in which they are used, including testing procedure.

C. Aluminum, iron, steel, brass, copper, bronze, galvanized steel, and stainless steel are commonly used and require isolation from each other with the following exceptions:

1. Iron and steel connected to each other.
2. Brass, copper, and bronze connected to each other.
3. Brass or bronze valves and specialties connected in closed systems with steel, iron, or stainless steel on both sides of the brass or bronze valves and specialties. Where two or more brass or bronze items occur together, they shall be connected with brass nipples. Brass or bronze valves and specialties cannot be used as a dielectric separation between pipe materials.

D. Dielectric protection is required at connections to equipment of a material different than the piping.

E. Screwed Joints (acceptable up to 2" size):

1. Dielectric waterway rated for 300 psi CWP and 225°F.
2. Manufacturers:

a. Elster Group ClearFlow fittings
b. Victaulic Series 647
c. Grinnell Series 407
d. Matco-Norca

F. Flanged Joints (any size):

1. Use 1/8" minimum thickness, non-conductive, full-face gaskets.
2. Employ one-piece molded sleeve-washer combinations to break the electrical path through the bolts.
3. Sleeve-washers are required on one side only, with sleeves minimum 1/32" thick and washers minimum 1/8" thick.
4. Install steel washers on both sides of flanges to prevent damage to the sleeve-washer.
5. Separate sleeves and washers may be used only if the sleeves are manufactured to exact lengths and installed carefully so the sleeves must extend partially past each steel washer when tightened.
6. Manufacturers:

a. EPCO
b. Central Plastics
c. Pipeline Seal and Insulator
d. F.H. Maloney
e. Calpico

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Valves/Fittings and Accessories:

1. Where a manual balance valve is shown to be installed in series with a service (isolation) valve, separate balance and service (isolation) valves shall be installed.
2. Install balancing valves with the manufacturer's recommended straight upstream and downstream diameters of pipe.
3. Prepare accessories for finish painting.
4. Install accessories with stems upright or horizontal, not inverted, except install manual quarter turn valves in radiation cabinets and all butterfly valves with stems horizontal.
5. Provide shutoff valves and flanges or unions at all connections to equipment, traps, and items that require servicing.
6. Provide flanges or unions at all final connections to equipment, traps and valves.
7. Arrange piping and piping connections so equipment may be serviced or totally removed without disturbing piping beyond final connections and associated shutoff valves.

END OF SECTION 23 21 16

SECTION 23 21 23 - HVAC PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. All pumps except where integral with a manufactured piece of equipment.

B. Pump controls where self-contained.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00.

B. Submit certified pump performance curves with pump and system operating point plotted. Include NPSH curve when applicable.

C. Submit motor data indicating compliance with Section 23 05 13.

PART 2 - PRODUCTS

2.1 PUMPS - GENERAL

A. Statically and dynamically balance rotating parts.

B. Construction shall permit complete servicing without breaking piping or motor connections.

C. Pumps shall operate at 1750 rpm unless specified otherwise.

D. Pump connections shall be flanged, whenever available.

E. Heating pumps shall be suitable for 225°F water.

F. Motors shall comply with Section 23 05 13.

G. Pump impellers shall not have smaller diameters than those scheduled. The inlet and discharge pipe sizes shall also meet or exceed the scheduled pump.

H. Pumps specified in this section operating in clean water with a flow greater than 25 GPM and less than 459 feet head shall have a maximum Pump Energy Index (PEI) as scheduled on the drawings. In no case shall the PEI exceed 1.0.

2.2 BASE MOUNTED END SUCTION PUMPS

A. Type: Centrifugal, single stage.

B. Casing: Cast iron, single suction, rated for greater of 150 psi or 1.25 times actual working discharge pressure, flanged suction and discharge with gauge ports.

C. Impeller: Bronze, fully enclosed, keyed to shaft.

D. Shaft: High grade alloy steel with copper, bronze or stainless steel shaft sleeves.

E. Bearings: Grease lubricated roller or ball bearings with grease fittings. If pump will be insulated, grease fittings shall be extended 3" with rigid pipe to clear the insulation.

F. Drive: Flexible coupling with OSHA-approved guard.

G. Seals: Mechanical type with internal flushing rated for -20 to 225°°F with Buna elastomer, carbon primary ring, and ceramic stationary ring.

H. Baseplate: Heat treated cast iron or reinforced heavy steel.

I. Manufacturers:

1. Bell & Gossett
2. Taco
3. Aurora
4. Armstrong
5. Grundfos/Peerless/PACO
6. Patterson
7. Weinman/Crane

2.3 IN-LINE PUMP

A. Type: Centrifugal, single stage, close coupled in-line, back pullout design, suitable for horizontal or vertical operation.

B. Casing: Cast iron, rated for greater of 125 psi or 1.5 times actual working discharge pressure, flanged suction and discharge with gauge ports.

C. Impeller: Bronze or stainless steel, fully enclosed, dynamically balanced, keyed to shaft and secured with locknut.

D. Shaft: Steel or stainless steel.

E. Seals: Mechanical type with internal flushing rated for -20 to 225°F and comprised of Buna elastomer, carbon primary ring, and ceramic stationary ring.

F. Manufacturers:

1. Bell & Gossett
2. Taco
3. Aurora
4. Armstrong
5. Grundfos/Peerless/PACO
6. Patterson
7. Weinman/Crane

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install all products per manufacturer's recommendations.
2. Support piping adjacent to pumps so that no weight is carried by pump casings. Provide supports under elbows on 4" and larger pump suction and discharge pipes. Allow a minimum of 18" clearance for removal of suction diffuser.
3. Ensure pumps operate at specified fluid temperatures without vapor binding or cavitation, are non-overloading in parallel or individual operation, and operate within 25% of midpoint of published maximum efficiency curve.
4. Install on vibration isolators as scheduled on drawings.

B. In-Line Pumps:

1. Support in-line pumps individually so there is no strain on the piping. Install with a minimum of five diameters of straight pipe on pump suction and discharge.
2. Pump orientation shall be in accordance with the manufacturer™™s recommendations.

C. Base-Mounted Pumps:

1. Base-mounted pump shall be aligned in accordance with the pump manufacturer™™s recommendations. A factory-trained representative shall laser align the pump to meet the manufacturer™™s requirements and tolerances. An alignment report shall be provided as part of the project closeout documents.
2. Unless otherwise shown on the drawings, mount all base mounted pumps on 4" high concrete pads and anchor frames to pads with cast-in-place anchors.
3. All base-mounted pumps shall be grouted-in. Follow manufacturer's instructions for grouting.

END OF SECTION 23 21 23

SECTION 23 22 00 - STEAM AND STEAM CONDENSATE PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe and Pipe Fittings.

B. Valves.

C. Steam Piping System.

D. Condensate Piping System.

1.2 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body. Remanufactured valves are not acceptable.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Store and protect piping to prevent corrosion and entrance of foreign matter.

B. Deliver and store valves in shipping containers with labeling in place.

1.4 REGULATORY REQUIREMENTS

A. Conform to ANSI/ASME B31.9 for the following pipe systems:

1. Boiler external pipe systems that operate up to 15 psi.
2. Non-boiler external pipe systems that operate up to 150 psi.

B. Conform to ANSI/ASME B31.1 for boiler external pipe systems that operate above 15 psi.

C. Refer to ANSI/ASME B31.1 and ANSI/ASME B31.9 for "boiler external piping" and "non-boiler external piping" definitions.

1.5 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 23 05 00 for required steam and steam condensate piping systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

PART 2 - PRODUCTS

2.1 STEEL PIPING (0 TO 125 PSIG)

A. Steel Pipe; 0 to 125psig; Standard Weight; Threaded Joints:

1. Design Pressure: 125 psig. Maximum Design Temperature: 353°F.
2. Pipe: Standard weight black steel, threaded and coupled, ASTM A53.
3. Joints: Screwed.
4. Fittings: 125 psi S - 175 psi. WOG, cast iron, ASTM A126, ANSI B16.4.
5. Unions: 250 psi S - 500 psi. WOG, black malleable iron, ground joint with brass seat.

B. Steel Pipe; 0 to 125psig; Standard Weight; Flanged Joints or Welded Joints:

1. Design Pressure: 125 psig. Maximum Design Temperature: 353°F.
2. Pipe: Standard weight black steel, beveled ends, ASTM A53.
3. Joints: Butt welded or flanged.
4. Fittings: Standard weight seamless steel, butt welded type, ASTM A234, Grade WPB, ANSI B16.9.
5. Flanges: 150 lb. forged steel, welding neck or slip-on, ASTM A181, Grade I, ANSI B16.5. Flange face seal weld (backweld) is required for slip-on flanges.

2.2 VALVES

A. Shutoff Valves:

1. BA-1: 3" and under, 125 psi saturated steam, 600 psi WOG, full port, screwed or solder ends (acceptable only if rated for soldering in line with 470°F melting point of lead-free solder), bronze body of a copper alloy containing less than 15% zinc, stainless steel ball and trim, Teflon seats and seals. Apollo #77C-140, Stockham #S-206 BR1-R, Milwaukee #BA-400, Watts, Nibco #585-70-66, National Utilities Co., RUB.
2. BA-1A (0 to 125 psig): 2-1/2" and 3", 150 psi saturated steam, 275 psi WOG ANSI Class, 150 psi standard port, carbon steel body stainless steel ball and trim, Teflon seats and seals. Apollo #88A-100, Nibco #F510-CS/66, Milwaukee #F90.

B. Throttling/Shutoff Valves:

1. Globe Valves (0 to 125 psig:

a. GL-1 (0 to 125 psig): 2" and under, 125 psi saturated steam, 300 psi WOG, screwed, bronze. Crane #7TF, Stockham #B22T, Walworth #3095, Milwaukee #590, Hammond #IB413, Watts #B-4010-T, NIBCO T-235-Y.
b. GL-2 (0 to 125 psig): 2-1/2" thru 10", 125 psi S @ 353°F, 200 psi WOG @ 150°F, flanged, iron body, bronze mounted. Crane #351, Hammond #IR116, Stockham #G-512, Walworth #8906F, Milwaukee #F2981, Watts #F-501, NIBCO F-718-B.

2.3 CHECK VALVES

A. CK-1 (0 to 125 psig): 2" and under, 125 psi S @ 353°F, 200 psi WOG @ 150°F, screwed, bronze, horizontal swing. Crane #37, Hammond #IB904, Stockham #B319, Walworth #3406, Milwaukee #509, Watts #B-5000, NIBCO T-413-Y.

B. CK-6 (0 to 125 psig): 2-1/2" thru 12", 125 psi S @ 353°F, 200 psi WOG @ 150°F, flanged, all iron, horizontal swing. Crane #373-1/2, Hammond #IR1126, Stockham #G933, Walworth #8928-1/2F, Milwaukee #F2971, Watts #F-511-R, NIBCO F-918-Ng.

2.4 STRAINERS

A. ST-1 (0 to 125 psig): Cast iron body, screwed ends, screwed cover, 250# steam @ 406°F, 400# WOG @ 150°F. Armstrong #CA1SC, Metraflex #TS, Mueller Steam Specialty Co. #11M, Sarco #IT, Watts #77S, NIBCO T-751. Bronze body strainer 125# may be used as contractor option.

B. Unless otherwise indicated, strainers shall have stainless steel screens with perforations as follows:

1. Steam All Sizes: 1/32"
2. Condensate All Sizes: 3/64"

C. Furnish pipe nipple with gate valve and threaded cap to blow down all strainer screens.

PART 3 - EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends, remove burrs, bevel plain end ferrous pipe.

B. Remove scale and dirt on inside and outside before assembly.

C. Remove all scale, rust, dirt, oils, stickers and thoroughly clean exterior of all bare metal exposed piping, hangers, and accessories .

D. Make connections to equipment with flanges or unions.

E. After completion, fill, clean, and treat systems.

3.2 PIPING SCHEDULE

A. Steam (0 to 125 psig):

1. Steel Pipe; 0 to 125 psig; Standard Weight; Threaded Joints: 2" and Under
2. Steel Pipe; 0 to 125 psig; Standard Weight; Flanged Joints or Welded Joints: 2-1/2" and Over
3. Shutoff Valves: BA-1, BA-1A
4. Throttling: GL-1, GL-2
5. Check Valves: CK-1, CK-6
6. Strainers: ST-1

B. Condensate Piping (0 to 125 psig):

1. Shutoff Valves: BA-1, BA-1A
2. Throttling: GL-1, GL-2
3. Check Valves: CK-1, CK-6
4. Strainers: ST-1

C. Boiler Feedwater (0 to 125 psig):

1. Steel Pipe; 0 to 125 psig; Extra Strong; Threaded Joints: 2" and Under
2. Shutoff Valves: BA-1, BA-1A
3. Throttling: GL-1, GL-2
4. Check Valves: CK-1, CK-6
5. Strainers: ST-1

3.3 TESTING PIPING

A. Complete all testing of pipes underground, or in chases and walls, before piping is concealed.

B. Complete all testing before insulation is applied, or if insulation is applied before the pipe is tested and a leak develops which ruins the insulation, the pipe installing contractor shall arrange and pay for replacing the damaged insulation.

C. Test piping with water at 150% of the maximum operating pressure.

D. Hold pressure for at least two hours.

E. Test to be witnessed by the Architect/Engineer or their representative, if requested by the Architect/Engineer.

3.4 CLEANING PIPING

A. Assembly:

1. Prior to assembly of pipe and piping components, all loose dirt, scale, oil and other foreign matter on internal or external surfaces shall be removed by means consistent with good piping practice subject to the approval of the Architect/Engineer's representative. Chips and burrs from machinery or thread cutting operation shall be blown out of pipe before assembly. Cutting oil shall be wiped from internal and external surfaces.
2. During fabrication and assembly, remove slag and weld spatter from both internal and external pipe joints by peening, chipping and wire brushing.
3. Notify the Architect/Engineer's representative prior to starting any post erection cleaning operation in sufficient time to allow witnessing the operation. Consult with and obtain approval from the Architect/Engineer's representative regarding specific procedures and scheduling. Arrange for proper disposal of cleaning and flushing fluids.
4. When the system is started up for the first time, discharge the condensate to drain per the boiler manufacturer's recommendations or for 24 hours, whichever is more restrictive. Add domestic cold water to the drain at a sufficient rate to reduce the condensate temperature to a maximum of 140°F.

3.5 INSTALLATION

A. General Installation Requirements:

1. Route piping in orderly manner, plumb and parallel to building structure, and maintain gradient.
2. Install piping to conserve building space and not interfere with use of space, other work, or equipment.
3. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

4. Slope steam piping 0.25" in 10 feet in direction of flow. Use eccentric reducers to maintain bottom of pipe level.
5. Slope steam condensate piping 0.5" in 10 feet.
6. Where pipe supports are welded to structural building framing, scrape, brush clean, and apply zinc rich primer to welds.

B. Installation Requirements in Electrical Rooms:

1. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment.

C. Valves/Fittings and Accessories:

1. Provide clearance for installation of insulation and access to valves and fittings.
2. Provide access doors where valves and fittings are not exposed.
3. Provide drip trap assembly at low points and before control valves and pressure reducing valves.
4. Provide loop vents over trapped sections.
5. Prepare pipe, fittings, supports, and accessories for finish painting.
6. Provide drip legs as shown on the drawings, at low points, traps, and the base of all risers in steam, and condensate pipes. Unless otherwise shown, drip legs shall be full pipe size on pipes through 4" and at least 4", but not less than half line size over 4". Drip legs shall be 12" minimum length, with a reducer and a 3/4"shutoff valve.
7. Install valves with stems upright or horizontal, not inverted.
8. Provide shutoff valves in supply and return to all equipment.
9. Install strainers in steam piping with the "wye" of the strainer to the side of the pipe in the horizontal plane to avoid pooling of condensate.

## 3.6 PIPE ERECTION AND LAYING

A. Carefully inspect all pipe, fittings, valves, equipment and accessories before installation. Any items that are unsuitable, cracked or otherwise defective shall be rejected and removed from the job immediately.

B. All pipe, fittings, valves, equipment and accessories shall have factory applied identification sufficient to determine conformance with specified requirements.

C. Exercise care at every stage of storage, handling, laying and erecting to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not erect or install any item that is not clean.

D. During construction, until system is fully operational, keep all openings in piping and equipment closed except when actual work is being performed on that item of system. Use plugs, caps, blind flanges or other items designed for this purpose.

E. Run pipe straight and true, parallel to building lines with minimum use of offsets and couplings. Provide only offsets required for needed headroom or clearance and to provide needed flexibility in piping.

F. Change direction of pipes only with fittings or pipe bends. Change size only with fittings. Do not use miter fittings, face or flush bushings, or street elbows. All fittings shall be long radius type, unless otherwise noted.

G. Provide flanges or unions at all connections to equipment traps and valves to facilitate dismantling.

H. Arrange piping and connections so equipment served may be serviced or totally removed without disturbing piping beyond final connections and associated shutoff valves.

I. Use full and double lengths of pipe wherever possible.

J. Unless otherwise indicated, install all inlet and outlet piping, including shutoff valves and strainers, to coils, pumps and other equipment at line size with reduction in size made only at control valve, pump, or trap.

K. Cut all pipe to exact measurement and install without springing or forcing.

L. Avoid creating, even temporarily, undue loads, forces or strains on valves, equipment or building elements with piping connections or supports.

M. Unless otherwise indicated, branch takeoffs shall be from top of mains or headers at either a 45° or 90° angle from the horizontal plane for steam pipes.

N. Branch takeoffs shall be from the top, side (if branch is two sizes smaller than main), or any angle from the horizontal plane to the top of piping for liquids.

3.7 BRANCH CONNECTIONS

A. Make branch connections with standard tee or cross fittings of the type required for the service unless otherwise indicated.

B. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it.

C. Branch connections from mains may be cut into black steel pipe using forged weld-on fittings:

1. Steam.
2. Condensate.
3. Boiler Feedwater.

D. Use of forged weld-on fittings is further limited as follows:

1. Must have at least same pressure rating as the main.
2. Header or main must be 2-1/2" or over.
3. Branch pipe is at least two sizes under main size.

3.8 JOINING OF PIPE

A. Threaded Joints (Steel Pipe):

1. Screw threads shall conform to ANSI B2.1 "Pipe Threads".
2. Ream pipe ends and remove all burrs and chips formed in cutting and threading.
3. Protect plated pipe and valve bodies from wrench marks.
4. Apply high temperature, anti-seize thread lubricant to male threads.

B. Welded Joints (Steel Pipe:

1. Welding of all pipe joints, both as to procedures and qualification of welders, shall be in accordance with Section IX, ASME "Boiler & Pressure Vessel Code" unless local codes take precedence.
2. Furnish to the Owner's Representative prior to start of work certificates qualifying each welder.
3. The Owner's Representative reserves the right to require qualifying demonstration, at the Contractor's expense, of any welders assigned to the job.
4. Ends of pipe and fittings to be joined by butt welding shall be beveled, cleaned to bare metal and internal diameters aligned before tack welding.

END OF SECTION 23 22 00

SECTION 23 22 18 - STEAM AND STEAM CONDENSATE SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Steam Traps

B. Condensate Return Units

C. Safety Valves

1.2 QUALITY ASSURANCE

A. Manufacturer: For each product specified, provide components by same manufacturer throughout.

B. Traps: Remanufactured traps are not acceptable.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 23 05 00. Include product description, model, dimensions, component sizes, rough-in requirements, service sizes, and finishes.

B. Submit schedule indicating manufacturer, model number, size, location, rated capacity, and features for each specialty.

C. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

D. Submit manufacturer's installation instructions.

E. Submit operation and maintenance data.

PART 2 - PRODUCTS

2.1 STEAM TRAPS

A. Furnish traps as scheduled on the drawings.

B. Type T-1: Inverted bucket type with thermic vent, 250 psig rated, cast iron body, side inlet and outlet, and all internal components constructed of stainless steel and renewable in-line.

1. Manufacturers (0-250 psig):

a. Armstrong Machine Works Series 800T
b. Spirax/Sacro Co., Inc. Type B
c. Hoffman Industrial Specialties Co. Series 600 T

d. Clark-Reliance Series 120

C. Type T-2: Thermostatic type with body and cap of cast brass, bronze bellows, stainless steel valve head and seat.

1. Manufacturers: (0-25 psig):

a. Spirax/Sacro Co., Inc. Type TD
b. Hoffman Industrial Specialties Co. Type C
c. Clark-Reliance Series T

D. Type T-3: Float and thermostatic type, 125 psig rated, cast iron body; balanced pressure thermostatic air vent; stainless steel valve seat, float, brass valve mechanism, and side inlet and outlet.

1. Manufacturers: (0-125 psig):

a. Armstrong Machine Works Type A
b. Hoffman Industrial Specialties Co. Series H, C, or X
c. Spirax/Sacro Co., Inc. Type FT
d. Clark-Reliance Type FT

2.2 LOW PRESSURE CONDENSATE RETURN UNITS (212°F210°F, ATMOSPHERIC VENTED, FLOOR MOUNTED TANK)

A. Units: Consist of factory assembled packaged receiver, pumps, float switches, control panel and accessories, for duplex operation.

B. Receiver: Floor mounted, 3/16" welded steel,, suitable for 212°F condensate, with inlets, outlets, vent, overflow, and drain connections, and lifting eye bolts.

C. Pumps: Centrifugal or vertical regenerative turbine type, rated to pump 212°F condensate, with two (2)-foot NPSHR. Cast iron case, renewable liners, bronze impeller, inducer impeller in addition to the centrifugal, stainless steel shaft, carbide/carbon mechanical seals rated for 250°F, with grease lubricated, sealed ball bearings, coupled to motor, 1750 RPM, and mounted on top or side of receiver. Refer to Section 23 05 13 for additional motor information.

D. Controls: Mechanical alternator shall be two pole; float switch shall start and stop pump. Provide control transformer for alternator if required for three-phase power.

E. Control Cabinet: Single point electrical connection, NEMA 1 or 2 enclosure, UL listed components, with hinged door, combination fused disconnect magnetic starters with overload relays, terminal strip, fusible control circuit transformer, and mechanical alternator. 'Hand-Off-Auto' switch, selector 'lead-off-lag' switches, test buttons, level alarm light, dry contacts for high level alarm, acknowledge button and alarm horn.

F. Control Sequence: Each pump control circuit shall be completely independent of the other. Operate pumps on high level, alternating after each cycle; operate second pump upon failure of first pump and alarm.

G. Accessories: , dial thermometer, pressure gauge on each pump discharge, isolation valves, double pole float switches, drain valve. Provide safety vapor release on receiver.

H. Manufacturer:

1. Roth Pump - Bulletin 1H99 Pg. 10 & 11
2. Domestic CB with "B" pumps 210°F
3. Shipco - ECC

2.3 VACUUM BREAKER

A. Spring loaded type selected or adjusted for the minimum possible opening pressure, but never over 11" water gauge.

B. Rated for 150 psig and 366°F.

C. Manufacturers:

1. Johnson VB8
2. Sarco VB14
3. B&G 26

PART 3 - EXECUTION

3.1 INSTALLATION AND APPLICATION

A. General Installation Requirements:

1. Install specialties in accordance with manufacturer's instructions.
2. Size traps to handle minimum of two and one-half times maximum condensate load of apparatus served, unless noted otherwise.
3. All traps shall be minimum 3/4" size.
4. Install traps with unions or flanges at both ends.
5. Provide shutoff valve and strainer at inlet, and check valve and shutoff valve at discharge of traps.
6. Provide minimum 14" long dirt pocket of same size as apparatus return connection between apparatus and trap, unless noted otherwise on drawings.
7. Remove thermostatic elements from traps during temporary and trial usage, and until system has been operated and dirt pockets cleaned of sediment and scale.

B. Condensate Return Unit: (Contractor note: does not apply to Flinn or Lincoln)

1. Install full-sized P-traps in the overflow drain piping from condensate return units and extend piping to nearest floor drain.

C. Safety Valve:

1. Rate safety valves for maximum capacity of largest available trim for pressure reducing valve(s) or maximum capacity of bypass valve(s), whichever is larger, at maximum possible pressure upstream of pressure reducing valve. Set at maximum 20 percent above reduced pressure.
2. Terminate safety valves outdoors. Provide drip pan elbow with drain connection to nearest floor drain.

END OF SECTION 23 22 18

SECTION 23 23 00 - REFRIGERATION PIPING AND SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Piping and Pipe Fittings

B. Moisture and Liquid Indicators

C. Check Valves

D. Pressure Relief Valves

E. Filter-Driers

F. Suction Filters

G. Solenoid Valves

H. Expansion Valves

I. Receivers

J. Suction Accumulators

1.2 QUALITY ASSURANCE

A. Remanufactured specialties are not acceptable.

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00.

B. Submit layout of entire piping system including equipment, critical dimensions, and all pipe sizes, traps, valves, and accessories. Layout shall be a custom drawing for this job, not a standard detail. The refrigeration equipment supplier shall stamp the approval on layout drawings.

C. Submit product data for specialties, including manufacturers catalog information.

D. Submit manufacturer's installation instructions.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store piping and specialties in shipping containers with labels in place.

B. Protect piping and specialties from entry of foreign material by leaving caps and plugs in place until installation.

PART 2 - PRODUCTS

2.1 PIPING

A. Design Pressure: 450 psig.

1. Maximum Design Temperature: 250°°F.

B. Piping - 4" and under; Brazed Joint:

1. Tubing: Type ACR hard drawn seamless copper tube, ASTM B280. Sizes indicated are nominal designation.
2. Joints: Brazed with silver solder.
3. Fittings: Wrought copper solder joint, ANSI B16.22.
4. Special Requirements: All tubing shall be cleaned, dehydrated, pressurized with dry nitrogen, plugged and tagged by manufacturer "for refrigeration service". During brazing operations, continuously purge the interior of the pipe with nitrogen to prevent oxide formation.

2.2 MOISTURE AND LIQUID INDICATORS

A. UL listed, with copper, brass, or copper-plated steel body, flared or solder ends, extended fittings in units up to at least 1-1/8" to allow brazing without removing the cartridge, sight glass, color coded paper moisture indicator that is replaceable without breaking piping connections for units up to 1-1/8" size, and plastic cap; maximum working pressure of 500 psi, and maximum temperature of 200°°F.

1. Manufacturers:

a. Sporlan
b. Henry Valve Company
c. Alco Valve

2.3 VALVES

A. BA-14: Refrigerant Ball Valve: 3/8" thru 3-1/8", 500 psi, -40°°F to +300°°F, full-port up to 2-1/8" size, blow-out proof, PTFE seals, brass ball with equalizing orifice, visible position indication, seal cap, extended copper connections, replaceable stem seals, compatible with all CFC, HCFC, and HFC refrigerants.

1. Manufacturers:

a. Henry Valve Company
b. Superior Valve
c. Alco Valve

2.4 CHECK VALVES

A. CK-10: 1/4" thru 3-5/8", 500 psi, globe or angle pattern, brazed, brass body, cleaned-dried-plugged and tagged at factory for refrigerant service.

1. Manufacturers:

    a. Henry Valve Company
    b. Mueller
    c. Wolf-Linde

2.5 PRESSURE RELIEF VALVES

A. RV-5: Straight Thru or Angle Type: Brass body and disc, Teflon seat, factory sealed and stamped with ASME UV and National Board Certification NB; selected to ANSI/ASHRAE 15.

2.6 FILTER-DRIERS

A. Replaceable Cartridge Angle Type: ANSI/AHRI 710, UL listed, brass or epoxy-coated steel shell, molded desiccant high-water capacity filter core(s); maximum working pressure of 500 psi; maximum temperature of 275°°F; maximum pressure drop of 3 psi with R410a or 1.5 psi with R134a at system flow rate.

B. Permanent Straight Thru Type: ANSI/AHRI 710, UL listed, steel shell with molded desiccant filter core, maximum working pressure of 500 psi, maximum pressure drop of 3 psi with R410a or 1.5 psi with R134a at system flow rate.

2.7 SUCTION FILTERS

A. Replaceable Cartridge Angle Type: UL listed for 500 psi up to 2-18" size, and 400 psi for larger sizes, steel shell that passes 1000-hour salt spray test with copper fittings, replaceable pleated filter element(s); maximum pressure drops of 3 psi with R410a or 2 psi with R134a at system flow rate, capable of accepting molded desiccant core for cleanup after compressor burnout, access valve in the removable end plate. Install with side refrigerant inlet.

2.8 SOLENOID VALVES

A. Valve: AHRI 760; pilot operated; copper or brass body and internal parts; synthetic seat; stainless steel stem and plunger assembly; extended solder ends to permit installation without disassembly; maximum working pressure of 500 psi; normally closed. Maximum pressure drop at system flow of 5 psi for R410a and 3 psi for R134a.

B. Coil Assembly: UL listed, replaceable with molded electromagnetic coil, moisture and fungus proof, surge protector and color-coded lead wires, integral junction box, Class F temperature rated, ANSI/UL 429.

2.9 EXPANSION VALVES

A. Angle or Straight Thru Type: ANSI/AHRI 750; materials suitable for system refrigerant, external equalizer, adjustable super heat setting, balanced port design, suitable for horizontal or vertical installation, with replaceable capillary tube and remote sensing bulb.

B. Selection: Evaluate refrigerant pressure drop through system to determine available pressure drop across valve. Select valve for maximum load at design operating pressure and minimum 10°°F super heat. Select to avoid being undersized at full load or excessively oversized at part load.

2.10 RECEIVERS

A. All receivers shall have capacity to hold the entire refrigerant charge when 90% full at 90°°F per ASHRAE 15-78.

B. 6" and Smaller Internal Diameter: ANSI/AHRI 495, UL listed, steel or copper, brazed; 450 psi working pressure, with tappings for inlet, outlet, and relief valve or fusible plug.

2.11 SUCTION ACCUMULATORS

A. All accumulators shall have capacity to hold 50% of the refrigerant charge when 90% full at 90°°F per ASHRAE 15-78, pressure drop equivalent to under 0.5°°F at peak capacity, a finish that survives a 500-hour salt spray test, vertical design with dip tube and screened oil inlet orifice, and a hot gas boil-out coil to evaporate liquid refrigerant.

B. 6" and Smaller Internal Diameter: ANSI/AHRI 495, UL listed, steel or copper, brazed; 400 psi pressure rating, with tappings for inlet, outlet, and pressure relief valve or fusible plug.

PART 3 - EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs.

B. Remove scale and dirt on inside and outside before assembly.

C. Remove all scale, rust, dirt, oils, stickers and thoroughly clean exterior of all bare metal exposed piping, hangers, and accessories in preparation to be painted.

3.2 INSTALLATION

A. Install specialties in accordance with manufacturer's instructions.

B. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it.

C. Route piping in orderly manner, parallel to building structure, and maintain gradient.

D. Install piping to conserve building space and not interfere with use of space.

E. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment.

F. Group piping whenever practical at common elevations and locations. Slope piping 1% in direction of oil return.

G. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

H. Provide clearance for installation of insulation and access to valves and fittings.

I. Where pipe support members are welded to structural building frame, brush clean, and apply zinc rich primer to welding.

J. Insulate piping and equipment; per Section 23 07 19 and Section 23 07 16.

K. Provide external equalizer piping on expansion valves, and locate expansion valve sensing bulb immediately downstream of evaporator on suction line. Connect distributor to expansion valve outlet.

L. Install flexible connectors parallel to the shafts of compressors.

M. Fully charge system with refrigerant after testing.

3.3 PIPE ERECTION AND LAYING

A. Carefully inspect all pipe, fittings, valves, equipment and accessories before installation. Any items that are unsuitable, cracked or otherwise defective shall be rejected and removed from the job immediately.

B. All pipe, fittings, valves, equipment and accessories shall have factory applied identification sufficient to determine their conformance with specified requirements.

C. Exercise care at all times to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not erect or install any item that is not clean.

D. During construction, until system is fully operational, keep all openings in piping and equipment closed except when actual work is being performed on that item or system. Closures shall be plugs, caps, blind flanges or other items designed for this purpose.

E. Change direction of pipes only with fittings or pipe bends. Change size only with fittings.

F. Cut all pipe to exact measurement and install without springing or forcing.

3.4 APPLICATION

A. Provide solenoid valves in liquid lines of systems, in oil bleeder lines to stop flow of oil and refrigerant into the suction line when system shuts down, and in hot gas bypass lines, as applicable.

B. Provide refrigerant charging valve connections.

C. Provide replaceable cartridge filter-driers, with three-valve bypass assembly and suction filters without bypass assembly.

3.5 JOINING OF PIPE

A. Brazed Joints:

1. Make up joints with brazing filler metal conforming to ANSI/AWS A5.8. Cut copper tubing ends perfectly square and remove all burrs inside and outside. Thoroughly clean sockets of fittings and ends of tubing to remove all oxide, dirt, and grease just prior to brazing. Apply flux evenly, but sparingly, to all surfaces to be joined. Brazing filler metal with a flux coating may also be used. Heat joints uniformly to proper brazing temperature so braze filler metal flows to all mated surfaces. Wipe excess braze filler metal, leaving a uniform fillet around cup of fitting.
2. Flux shall conform to ANSI/AWS A5.31.
3. Remove composition discs and all seals during brazing if not suitable for a minimum of 840°°F or greater than the melting temperature of the brazing filler metal, whichever is greater.

3.6 FIELD QUALITY CONTROL

A. Test piping system with nitrogen at 300 psig for at least 8 hours without loss of pressure.

B. Comply with ASHRAE Standard 147 for refrigerant system integrity testing.

C. After pressure testing, evacuate all refrigerant piping to at least 28" of mercury for 24 hours without loss of vacuum. Ensure moisture does not enter the piping prior to and during the tests.

END OF SECTION 23 23 00

SECTION 23 25 00 - CHEMICAL (WATER) TREATMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Treatment for Closed Systems (Water).

B. Chemical Feed Equipment.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00.

B. Include system schematics, equipment locations, and controls schematics.

C. Submit product data indicating chemicals and equipment.

D. Submit manufacturer's installation instructions.

E. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

F. Submit reports indicating start-up of treatment systems is completed and operating properly. Include reports indicating analysis of system water after cleaning and after treatment.

1.3 EXTRA STOCK

A. Provide clean cartridges or bags in all bypass (pot) feeders with filters and sidestream filters.

B. Provide two complete sets of replacement cartridges or filters for each bypass (pot) feeder with filters and sidestream filter installed. Deliver to Owner at job site.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include data on pumps and other equipment including spare parts lists, procedures, and treatment programs.

C. Include step-by-step instructions on test procedures including target concentrations and test frequencies.

D. Include list of treatment chemicals and associated SDS.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum five years documented experience. Company shall have local representatives with water analysis laboratories and full-time service personnel.

1.6 REGULATORY REQUIREMENTS

A. Conform to all applicable codes and regulations for addition of non-potable chemicals to building mechanical systems, and for discharge to public sewage systems.

B. Provide only chemicals approved for use and disposal by local authorities. Contact the Architect/Engineer if any specified chemicals are prohibited.

1.7 MAINTENANCE SERVICE

A. Provide the following services to assist the owner in setting up and maintaining chemical treatment systems for one year from Date of Substantial Completion:

1. Provide technical service visits to perform field inspections and make water analysis on site. Visits shall be twice annually for closed systems and monthly for steam and cooling tower systems. For cooling tower systems, monthly testing shall have dipslide culture counts, and quarterly water samples shall be sent to a CDC Elite lab for culturing to establish baseline total organism and Legionella counts. Detail findings in writing on proper practices, chemical treating requirements, and corrective actions needed. Submit copies of the field service report after each visit to the Owner and to the Mechanical Contractor. Any problems related to the operation of the chemical treatment program shall be reported to the Architect/Engineer.
2. Provide laboratory and technical assistance services for warranty period.
3. Include 2 hour training course for operating personnel, instructing them on installation, care, maintenance, testing, and operation of water treatment systems. Arrange course at start-up of systems.
4. Provide on-site inspections of equipment during scheduled or emergency shutdown to properly evaluate success of water treatment program, and make recommendations in writing based upon these inspections.
5. Provide sufficient chemicals for treatment and testing during warranty period.

B. The Chemical Treatment Subcontractor shall be responsible for assisting the Mechanical Contractor by adding the chemical solutions required for cleaning each piping system. During the remainder of the warranty period, the Chemical Treatment Subcontractor will be responsible for adding chemicals and doing other work related to the operation of system such as boiler blowdown. The Chemical Treatment Contractor shall make periodic tests of the chemical treatment program as called for above and recommend changes to Owner when needed.

1.8 WATER ANALYSIS

A. Sample feedwater to determine appropriate chemical treatment. Contact the Architect/Engineer if test indicates treatment required is different than that specified.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. America's Best Water Treaters

B. Betz

C. Butler Cheical Company

D. H-O-H Chemicals Inc.

E. Watertech of America

2.2 MATERIALS

A. Closed System Treatment (Water):

1. Provide one bypass feeder on each system. Install inlet, outlet and drain valves, and necessary piping.
2. Provide a 3/4" water meter in the domestic cold water line that provides makeup water to hydronic systems with electronic pulse output to building automation system.
3. Provide coupon rack around main system pumps for all systems
4. Proprietary blend containing the following items:

a. Corrosion Inhibitors for Chilled Water Systems and Heating Systems operating at ≤145°F:Sodium molybdate with added inhibitors such as mercaptobenzothiazole, sodium tolytriazole, or phenyltriazole to protect copper and brass and minimize dielectric pitting of steel. Maintain 50 ppm molybdate. Adjust borax content to keep correct pH for type of system (mainly steel or mainly copper).
b. Scale Inhibitor: Organic phosphonates such as aminomethylene-phosphonate; phosphonates such as hydroxyethylidenediphosphonate or polyamino-substituted phosphonates; or synthetic polymers such as low-molecular-weight polyacrylates, poly-methacrylates and polyacrylanides. Inorganic phosphates are not acceptable. Maintain residual concentration as recommended by the manufacturer.

2.3 EQUIPMENT

A. Bypass (Pot) Feeder: 5.0 gal; quick-opening cap with 3-1/2" minimum diameter opening and opening wrench, legs to raise fill cap to 30" to 36", drain valve, air cock, working pressure of 200 psig at 200°F, 20 to 25-micron cartridge or bag filter.

1. Acceptable Manufacturers:

a. Griswold
b. Vector Industries
c. J.L. Wingert
d. Neptune

B. Water Meter: Positive displacement type meter with bronze housing. 3/4" meter size. Meter to handle 1/2 - 30 GPM.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install bypass (pot) feeder with top approximately 36" above the floor.

C. Coordinate with Contractor to provide temporary metering capabilities during system fill to determine overall system volume. Notify Architect/Engineer of overall system volume so that expansion tank sizing can be confirmed.

3.2 CLOSED-LOOP HYDRONIC SYSTEM WATER QUALITY STANDARDS

A. Review equipment manufacturer's water quality standard to ensure water quality is sufficient to meet their warranty requirements as well as to ensure peak heat transfer efficiency. Contractor shall maintain hydronic systems within the more stringent of either the equipment manufacturer's requirements or those listed below:

| Measured Value | Multi-Metal Systems with Aluminum | Multi-Metal Systems with Stainless Steel | Multi-Metal Systems with Copper |
|---|---|---|---|
| pH Range | 8.5 | 8.5 | 9.0 |
| Alkalinity as $CaCO_3$ | 100 - 500 mg/l | 100 - 500 mg/l | 100 - 500 mg/l |
| Hardness as $CaCO_3$* | 100 - 500 mg/l | 100 - 500 mg/l | 100 - 500 mg/l |
| Suspended Solids | less than 10 mg/l | less than 10 mg/l | less than 10 mg/l |
| Dissolved Solids | less than 1,000 mg/l | less than 1,000 mg/l | less than 1,000 mg/l |
| Chlorides | less than 150 mg/l | less than 150 mg/l | less than 150 mg/l |
| Iron | less than 5.0 mg/l | less than 5.0 mg/l | less than 5.0 mg/l |
| Manganese | less than 0.4 mg/l | less than 0.4 mg/l | less than 0.4 mg/l |
| Nitrate | less than 100 mg/l | less than 100 mg/l | less than 100 mg/l |
| Sulfate | less than 200 mg/l | less than 200 mg/l | less than 200 mg/l |
| Ammonia | less than 5.0 mg/l | less than 5.0 mg/l | less than 5.0 mg/l |
| Free Copper | less than 0.10 mg/l | less than 0.10 mg/l | less than 0.10 mg/l |

* Minimum hardness only applies to softened water. If water from rivers or lakes is below 100 mg/l, remineralizing is not required.

B. Submit an independent third-party test report for each chemically treated closed-loop system showing compliance with all measured values shown in the above table as part of project closeout documentation.

END OF SECTION 23 25 00

SECTION 23 31 00 - DUCTWORK

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Galvanized Ductwork

B. Ductwork Reinforcement

C. Ductwork Sealants

D. Rectangular Ductwork

E. Round Ductwork

F. Exposed Ductwork (Rectangular, Round)

G. Flexible Duct

H. Ductwork Penetrations

1.2 QUALITY ASSURANCE

A. Building Codes and Standards:

1. Product must be classified by Underwriter's Laboratories in accordance with the 25/50 flame spread / smoke developed requirements of NFPA 90-A and UL 2518.
2. All product sections must be labeled with the logo and classification marking of Underwriter's Laboratories.

B. Design and Quality Control:

1. Manufacturer must have documented design support information including duct sizing; vent, orifice, and/or nozzle location; vent, orifice, and/or nozzle sizing; length.

1.3 SUBMITTALS

A. Submit shop drawings per Section 23 05 00.

B. The Architect/Engineer may require field verification of sheet metal gauges and reinforcing to verify compliance with these specifications. At the request of the Architect/Engineer, the contractor shall remove a sample of the duct for verification. The contractor shall repair as needed.

C. Duct Layout Drawings: Submit detailed duct layout drawings at 1/4" minimum scale complete with the following information:

1. Actual duct routing, ductwork fittings, actual sheet metal dimensions including insulation liner and wrap, duct hanger and support types, ductwork accessories, etc. with lengths and weights noted.
2. Differentiate ducts that are wrapped. Include insulation thickness, type of insulation, and acoustical lagging.
3. Room names and numbers, ceiling types, and ceiling heights.
4. Indicate location of all beams, bar joists, etc. along with bottom of steel elevations for each member.
5. Verify clearances and interferences with other trades prior to preparing drawings. IMEG will provide electronic copies of ventilation drawings for contractor's use if the contractor signs and returns the "Electronic File Transfer" waiver. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for this submittal. Refer also to Section 23 05 00.

D. Duct Leakage Test Summary Report: Upon completion of the pressure test described in Part 3, the Contractor shall submit an air duct leakage test summary report as outlined in the SMACNA HVAC Duct Leakage Test Manual.

1.4 WARRANTY

A. Manufacturer must provide a 15-year product warranty.

1.5 DELIVERY, STORAGE AND HANDLING

1. Protect textile air dispersion systems from damage during shipping, storage and handling.
2. Where possible, store products inside and protect from weather. Where necessary to store outside, store above grade and enclose with a vented waterproof wrapping.

1.6 DEFINITIONS

A. Duct Sizes shown on drawings are inside clear dimensions. Maintain clear dimensions inside any lining.

B. Transitions are generally not shown in single-line ductwork. Where sizes change at a divided flow fitting, the larger size shall continue through the fitting.

C. Exterior Duct: Ductwork located outside the conditioned envelope including exposed ductwork above the roof, outside exterior walls, in attics above insulated ceilings, inside parking garages, and crawl spaces.

D. Interior Duct: Ductwork located within the conditioned envelope including return air plenums and indirectly conditioned spaces.

1.7 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 23 05 00 for required duct systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

B. Duct drawings shall be at 1/4" minimum scale complete with the following information:

1. Actual duct routing, ductwork fittings, actual sheet metal dimensions including insulation liner and wrap, duct hanger and support types, ductwork accessories, etc. with lengths and weights noted.
2. Differentiate ducts that are lined or wrapped. Include insulation thickness, type of insulation, and acoustical lagging.
3. Location and size of all duct access doors.
4. Room names and numbers, ceiling types, and ceiling heights.
5. Indicate location of all beams, bar joists, etc. along with bottom of steel elevations for each member.
6. IMEG will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings. Architectural plans will need to be obtained from the Architect.

## PART 2 - PRODUCTS

### 2.1 SHAPE

A. Rectangular Duct - Single Wall:

1. General Requirements:

a. All ductwork gauges and reinforcements shall be as listed in SMACNA Duct Construction Standards Chapter 2. Where necessary to fit in confined spaces, furnish heaviest duct gauge and least space consuming reinforcement.
b. Transitions shall not exceed the angles in Figure 4-7.

2. Exceptions and modifications to the HVAC Duct Construction Standards are:

a. All ducts shall be cross-broken or beaded.
b. Snap lock seams are not permitted.
c. Turning vanes shall be used in all 90° mitered elbows, unless clearly noted otherwise on the drawings. Vanes shall be as follows:

1) Type 2:

a) Description: Double wall type with 3-1/4" blade spacing, 4-1/2" radius, 24-gauge minimum, and SMACNA Type 1 runners. C-value below 0.27.
b) Usage: No limits other than imposed by the manufacturer. Provide intermediate support for vanes over 48" long.

d. Where smooth radius rectangular elbows are shown, they shall be constructed per SMACNA Figure 4-2. Type RE1 shall be constructed with a centerline duct radius R/W of 1.0. Where shown on drawings, Type RE3 elbows with 3 vanes shall be used with centerline duct radius R/W of 0.6 (SMACNA r/W=0.1). RE1 or RE3 elbows may be used where mitered elbows are shown if space permits. Mitered elbows (with or without turning vanes) may not be substituted for radius elbows. Do not make branch takeoffs within 4 duct diameters on the side of the duct downstream from the inside radius of radius elbows.

e. Rectangular branch and tee connections in ducts over 1" pressure class shall be 45° entry type per Figs. 4-5 and 4-6. Rectangular straight taps are not acceptable above 1" pressure class.

f. Bellmouth fittings shown on return duct inlets shall expand at a 60-degree total angle horizontally and vertically (space permitting) and have length of at least 25% of the smallest duct dimension.

g. Round taps off rectangular unlined ducts shall be flanged conical or bellmouth type (equal to Buckley Bellmouth or Sheet Metal Connectors E-Z Tap), or 45° rectangular with transition to round (equal to Sheet Metal Connectors Inc. High Efficiency Takeoff). Straight taps are acceptable if pressure class is 1" or less, round duct is 12" diameter or less, and the tap is not located between fans and TAB devices.

h. Duct offsets shall be constructed as shown on drawings. Additional offsets required in the field shall be formed of mitered elbows without turning vanes for offsets up to 30° maximum angle in accordance with SMACNA offset Type 2. Offsets of greater than 30° angle shall be formed of radius elbows with centerline radius R/W=1.0 or greater. SMACNA Type 1 offsets are not permitted.

i. Cushion heads are acceptable only downstream of TAB devices in ducts up to ± 2" pressure class, and must be less than 6" in length.

j. Slide-on flanged transverse joint systems are acceptable provided they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.

    1) Apply sealant to all inside corners. Holes at corners are not acceptable.
    2) Manufacturers:

        a) Ductmate Industries - 25/35/45
        b) Nexus
        c) Mez
        d) WDCI
        e) Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer's approval before any fabrication begins.

k. Formed-on flanged transverse joint systems are acceptable provided they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.

    1) Apply sealant to all inside corners. Holes at corners are not acceptable.
    2) Flanges shall be 24-gauge minimum (not 26 gauge).
    3) Manufacturers:

a) Lockformer TDC
b) TDF
c) United McGill
d) Sheet Metal Connectors
e) Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer's approval before any fabrication begins.

B. Rectangular Duct - Double Wall:

1. All applicable portions of Rectangular Duct - Single Wall shall apply.
2. Furnish and install double-wall insulated airtight duct as shown on the drawings.
3. Duct Construction:

a. Galvanized steel exterior wall with solid galvanized steel interior wall.
b. Rectangular double wall duct shall be suitable for pressures listed in the ductwork application schedule.

c. All ductwork gauges and reinforcement shall be as listed in SMACNA Duct Construction Standards Chapter 2. Where necessary to fit in confined spaces, furnish heaviest duct gauge and least space-consuming reinforcement.
d. Ducts shall be 1-1/2" thick and completely metal enclosed with annular space completely filled with 1-1/2# density glass fiber insulation. Insulation shall have flame spread/smoke developed ratings of less than 25/50 per ASTM E84, NFPA 255, or UL 723.
e. Divided flow fittings may be separate fittings or factory installed taps with the following construction requirements:

1) Airtight, continuous welds at intersection of fitting body and tap.
2) Tap liner spot welded to inner liner with weld spacing not over 3".
3) Insulation packed around the tap area for complete cavity filling.
4) Carefully fit branch connections to cut-out openings in inner liner without spaces for air erosion of insulation or sharp projections for noise and airflow disturbance.

f. Spot weld and bond all fitting seams in the pressure shell. Coat galvanizing damaged by welding with corrosion resistant paint to match galvanized duct color.
g. Support inner liner of ducts and fittings with metal spacers welded to maintain spacing and concentricity.
h. Formed-on flanged transverse joint systems are acceptable if they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.

1) Apply sealant to all inside corners. Holes at corners are not acceptable.
2) Flanges shall be 24-gauge minimum (not 26 gauge).
3) Manufacturers, Formed-on Flanged Joint Systems:

a) Lockformer TDC
b) TDF
c) United McGill

d) Sheet Metal Connectors
e) Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer's approval before any fabrication begins.

C. Round Spiral Seam Ductwork - Single Wall:

1. Conform to applicable portions of Rectangular Duct Section. Round or flat oval ductwork may be substituted for rectangular ductwork where approved by the Architect/Engineer. The spiral seam ductwork shall meet the standards set forth in this specification. The ductwork shall meet or exceed the specified cross-sectional area and insulation requirements. The substitution shall be coordinated with all other trades prior to installation.
2. Flat oval duct in negative pressure applications shall have flat sides reinforced as required for rectangular ducts of the same gauge with dimensions equal to the flat span of the oval duct.
3. 90° elbows shall be smooth radius or have a minimum of five sections with mitered joints and R/D of at least 1.5.
4. Duct and fittings shall meet the required minimum gauges listed in chapter 3 of the SMACNA requirements for the specified pressure class. Ribbed and lightweight duct are not permitted.
5. Ductwork shall be suitable for velocities up to 5,000 fpm.
6. Divided flow fittings may be made as separate fittings or factory installed taps with sound, airtight, continuous welds at intersection of fitting body and tap.
7. Spot weld and bond all fitting seams in the pressure shell. Coat galvanizing damaged by welding with corrosion resistant paint to match galvanized duct color.
8. Ducts with minor axis less than 22" shall be spiral seam type. Larger ducts may be rolled, longitudinal welded seam type. SMACNA seams RL-2 and RL-3 are not permitted.
9. Reinforce flat oval ducts with external angles. Internal tie rods are permitted only as indicated for rectangular ductwork.
10. Transverse Joint Connections:

a. Crimped joints are not permitted.
b. Ducts and fittings 36" in diameter and smaller shall have slip joint connections. Size fitting ends to slip inside mating duct sections with minimum 2-inch insertion length and a stop bead. Use inside slip couplings for duct-to-duct joints, and outside slip couplings for fitting-to-fitting joints.
c. Ducts and fittings larger than 36" shall have flanged connections.
d. Secure all joints with at least 3 sheet metal screws before sealing.
e. Manufacturers:

1) Slide-on Flanges:
2) Ductmate Industries - SpiralMate
3) Accuflange
4) Sheet Metal Connectors are acceptable.

2.2 MATERIAL AND APPLICATION SPECIFIC

A. Galvanized Steel:

1. General Requirements:

a. Duct and reinforcement materials shall conform to ASTM A653 and A924.
b. Interior Ductwork and reinforcements: G60 galvanized (0.60 ounces per square foot total zinc coating for two sides per ASTM A90) unless noted otherwise.
c. Exterior Ductwork: G90 galvanized (0.90 ounces per square foot total zinc coating for two sides per ASTM A90) unless noted otherwise. G60 is not acceptable for exterior use.
d. Ductwork reinforcement shall be of galvanized steel.

2. Duct Hangers and Support:

a. Ductwork supports shall be of galvanized or painted steel.
b. Aircraft cable and slip cable hangers are acceptable for ducts up to 18"ø. Protective sleeve tubing shall be used on the cable when supporting duct with exterior insulation. Corner saddles are required when supporting rectangular ductwork.

1) Manufacturers; Supports:

a) Gripple
b) Ductmate
c) Duro Dyne
d) Architect/Engineer approved

## 2.3 DUCTWORK REINFORCEMENT

A. All reinforcement shall be external to the duct except that tie rods may be used with the following limitations.

1. Ducts must be over 18" wide.
2. Duct dimensions must be increased 2" in one dimension (h or w) for each row of tie rods installed.
3. Tie rods must not exceed 1/2" diameter.
4. Manufacturer of tie rod system must certify pressure classifications of various arrangements, and this must be in the shop drawings.

## 2.4 DUCTWORK SEALANTS

A. One-part joint sealers shall be water-based mastic systems that meet the following requirements: maximum 48-hour cure time, service temperature of -20°F to +175°F, resistant to mold, mildew and water, flame spread rating below 25 and smoke-developed rating below 50 when tested in accordance with ASTM E84, suitable for all SMACNA seal classes and pressure classes. Mastic used to seal flexible ductwork shall be marked UL 181B-M. Joint sealers for use on exterior weather exposed ductwork shall be rated for -30°F to +175°F and 2000-hour minimum UV resistance per ASTM G-53.

B. Two-part joint sealers shall consist of a minimum 3" wide mineral-gypsum compound impregnated fiber tape and a liquid sealant. Sealant system shall meet the following requirements: maximum 48-hour cure time, service temperature of 0°F to 200°F, resistant to mold, mildew, and water, flame spread rating below 25 and smoke developed rating below 50 when tested in accordance with ASTM E84, suitable for all SMACNA seal classes and pressure classes. Joint sealers for use on exterior weather exposed ductwork shall be rated for -30°F to +175°F and 2000-hour minimum UV resistance per ASTM G-53.

2.5 FLEXIBLE DUCT

A. Flexible duct shall be listed and labeled as UL 181 Class 1 Air Duct Material, and shall comply with NFPA 90A and 90B, and meet GSA, FHA and other U.S. Government agency standards. Flexible duct shall bear the ADC Seal of Certification.

B. Flame Spread/Smoke Developed: Not over 25/50.

C. Stretch all flexible duct to prevent sags and reduce air friction. Shorten and reinstall all sagging or loose flexible duct. Avoid sharp elbows. Elbows shall maintain 1.5 diameter centerline turning radius.

D. Install per the SMACNA Flexible Duct Manual. Secure inner layer with draw band. Wrap with pressure sensitive tape for protection prior to installing draw band. Pressure sensitive tape alone is not acceptable.

E. Acoustic:

1. Flexible duct shall be acoustic rated in accordance with ASTM E477 and ADC Test Code FD 72-RI by ETL. Insertion loss values noted below are for flow velocities less than 2,500 fpm. Submittals shall include insertion losses ratings per sizes and lengths listed below regardless of sizes shown on the drawings.
2. Flexible have corrosion-resistant wire helix, bonded to a nylon fabric core inner liner that prevents air from contacting the insulation, covered with minimum 1-1/2", 3/4 lb/cf density fiberglass insulation blanket, sheathed in a vapor barrier of metalized polyester film laminated to glass mesh. .
3. Inner liner shall be airtight and suitable for 6" WC static pressure through 16" diameter. Outer jacket shall act as a vapor barrier only with permeance not over 0.1 perm per ASTM E96, Procedure A. "R" value shall not be less than 4.0 ft2*ºF*hr/Btuh. Temperature range of at least 0-180ºF. Maximum velocity of 4,000 fpm.
4. Minimum Acoustic Insertion Losses per octave band:

a. Straight Duct:

| Dia | Length | 63hz | 125hz | 250hz | 500hz | 1000hz | 2000hz | 4000hz |
|---|---|---|---|---|---|---|---|---|
| 6" ø | 6 ft | 4.0 | 13 | 15 | 15 | 16 | 17 | 16 |
| 6" ø | 3 ft | 2.3 | 4.9 | 5.3 | 5.3 | 5.5 | 5.8 | 5.4 |
| 8" ø | 6 ft | 5.7 | 14 | 13 | 15 | 16 | 18 | 16 |
| 8" ø | 3 ft | 2.9 | 5.0 | 4.9 | 5.7 | 5.6 | 5.8 | 5.6 |
| 12" ø | 6 ft | 5.5 | 13 | 12 | 15 | 15 | 18 | 13 |
| 12" ø | 3 ft | 2.8 | 4.8 | 4.7 | 5.3 | 5.3 | 5.8 | 4.9 |

b. 90deg Elbow:

| Dia | Length | 63hz | 125hz | 250hz | 500hz | 1000hz | 2000hz | 4000hz |
|---|---|---|---|---|---|---|---|---|
| 6" ø | 6 ft | 10 | 15 | 16 | 17 | 18 | 17 | 18 |
| 6" ø | 3 ft | 3.8 | 5.4 | 5.5 | 5.7 | 5.9 | 5.8 | 5.9 |
| 8" ø | 6 ft | 10 | 15 | 16 | 17 | 16 | 18 | 18 |

| Dia | Length | 63hz | 125hz | 250hz | 500hz | 1000hz | 2000hz | 4000hz |
|---|---|---|---|---|---|---|---|---|
| 8" ø | 3 ft | 2.4 | 5.3 | 5.6 | 5.8 | 5.6 | 5.9 | 6.0 |
| 12" ø | 6 ft | 11 | 14 | 15 | 16 | 15 | 16 | 15 |
| 12" ø | 3 ft | 4.4 | 5.1 | 5.3 | 5.5 | 5.4 | 5.6 | 5.3 |

5. Usage:

   a. Take-offs from supply ducts to inlets of terminal air boxes. Do not exceed 36" in length.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide openings in ducts for thermometers and controllers.

B. Locate ducts with space around equipment for normal operation and maintenance.

C. Do not install ducts or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the electrical equipment. Unless intended to serve these rooms, do not install any ductwork or equipment in electrical rooms, transformer rooms, electrical closets, telephone rooms or elevator machine rooms.

D. Provide temporary closures of metal or taped polyethylene on open ducts to prevent dust from entering ductwork.

E. Supply ductwork shall be free of construction debris, and shall comply with Level "B" of the SMACNA Duct Cleanliness for New Construction Guidelines.

F. Repair all duct insulation and liner tears.

G. Install manual volume dampers in branch supply ducts so all outlets can be adjusted. Do not install dampers at air terminal device or in outlets, unless specifically shown.

H. Install flexible duct in accordance with the ADC Flexible Duct Performance and Installation Standards.

I. Flexible duct shall NOT be joined to flat-oval connections. Provide sheet metal oval-to-round transitions where required, to include, but not limited to, all connections to air inlets, air outlets, and terminal air boxes.

J. Install all exterior ductwork per SMACNA Fig. 6-3. Where drawings do not indicate otherwise, ductwork seams and joints shall be sealed watertight and pitched to shed water.

K. Support all duct systems in accordance with the SMACNA HVAC Duct Construction Standards: Metal and Flexible and the SMACNA Seismic Restraint Manual: Guidelines for Mechanical Systems, where applicable. Refer to Section 23 05 50 for seismic requirements.

L. Adhesives, sealants, tapes, vapor retarders, films, and other supplementary materials added to ducts, plenums, housing panels, silencers, etc. shall have flame spread/smoke developed ratings of under 25/50 per ASTM E84, NFPA 255, or UL 723.

M. All duct support shall extend directly to building structure. Do not support ductwork from pipe hangers unless coordinated with piping contractor prior to installation. Do not allow lighting or ceiling supports to be hung from ductwork or ductwork supports.

3.2 DUCTWORK APPLICATION SCHEDULE

A. General:

1. Seal Class is per SMACNA HVAC Air Duct Leakage Test Manual
2. Insulation:

a. Refer to Section 23 07 13 for insulation types.
b. Type A insulation (Flexible Fiberglass Wrap) R-values noted are based on installed values (25% compression).

SPECIFIER: This note is intended for DOAS systems where flows are typically small and small amounts of leakage can severely affect overall operation. This note can be left in for all systems if desired.Note 1: Apply aluminum based adhesive sealant tape at non-flanged joints on ducts serving dedicated outside air supply (DOAS) and exhaust system in addition to Class A sealant.

B. Duct System Description: Exterior Supply/Return - Ductwork on roof from unit connection to roof penetration:

1. Shape: Round or Rectangular Duct (as shown on plans) - Double Wall
2. Material: Galvanized Steel
3. Pressure Class: +4"
4. Seal Class: A
5. Insulation: IECC-2018: 3" thick Type E (R=12)
6. Additional Requirements: None

C. Duct System Description: Interior Supply, including internal to curb from unit connection to outlet:

1. Shape: Round - Round Spiral Seam Ductwork - Double Wall
2. Material: Galvanized Steel
3. Pressure Class: +4"
4. Seal Class: A
5. Insulation: 1-1/2" thick Type E (R=4.5)
6. Additional Requirements: None

D. Duct System Description: Interior Return from unit connection to bell mouth opening:

1. Shape: Rectangular - Rectangular - Double Wall
2. Material: Galvanized Steel
3. Pressure Class: +3"
4. Seal Class: A
5. Insulation: 1-1/2" thick Type E (R=4.5)

6. Additional Requirements: None

E. Duct System Description Interior Supply/Return, including internal to curb from unit connection to outlet:

1. Shape: Round or Rectangular Duct - Single Wall
2. Material: Galvanized Steel
3. Pressure Class: +3" Supply, -2" Return
4. Seal Class: A
5. Insulation: 1-1/2" thick Type A (R=4.5)
6. Additional Requirements: None

F. Duct System Description Interior Room Neutral Temp Supply/Return/Exhaust from unit or curb connection to outlet:

1. Shape: Round or Rectangular Duct (as shown on plans) - Single Wall
2. Material: Galvanized Steel
3. Pressure Class: +3" Supply, -2" Return and Exhaust
4. Seal Class: A
5. Insulation: None - (room neutral temperature air)
6. Additional Requirements: None

G. Duct System Description Interior Supply/Exhaust - from unit connection to vertical riser in tunnel/plenum:

1. Shape: Rectangular Duct - Single Wall
2. Material: Galvanized Steel
3. Pressure Class: +4" Supply, -4" Exhaust
4. Seal Class: A
5. Insulation: 1-1/2"thick Type A (R=4.5)
6. Additional Requirements: None

H. Duct System Description Interior Ducted Units (FCU, ) - Supply/Return from unit connection to outlet:

1. Shape: Round or Rectangular Duct (as shown on plans) - Single Wall
2. Material: Galvanized Steel
3. Pressure Class: +2" Supply, -2" Return
4. Seal Class: A
5. Insulation: 1-1/2" thick Type G (Round Duct) Liner (R=4.5)
6. Insulation: 1 -1/2" thick Type I (Rectangular Duct) Liner (R=4.5)
7. Additional Requirements: None

3.3 DUCTWORK SEALING

A. General Requirements:

1. Openings, such as rotating shafts, shall be sealed with bushings or similar.
2. Pressure sensitive tape shall not be used as the primary sealant unless it has been certified to comply with UL-181A or UL-181B by an independent testing laboratory and the tape is used in accordance with that certification.

3. All connections shall be sealed including, but not limited to, taps, other branch connections, access doors, access panels, and duct connections to equipment. Sealing that would void product listings is not required. Spiral lock seams need not be sealed.
4. Mastic-based duct sealants shall be applied to joints and seams in minimum 3 inch wide by 20 mil thick bands using brush, putty knife, trowel, or spray, unless manufacturer's data sheet specifies other application methods or requirements.

B. All ducts systems, regardless of pressure class, shall be Seal Class A as defined by Section 5-1 of SMACNA HVAC Air Duct Leakage Test Manual per the Energy Code, unless specifically noted otherwise. Seal Class A shall include sealing of all transverse joints, longitudinal seams, and duct wall penetrations with welds, gaskets, mastics, or fabric-embedded mastic system. Joints are inclusive of, but not limited to, girth joints, branch and sub-branch intersections, duct collar tap-ins, fitting subsections, louver and air terminal connections to ducts, access door and access panel frames and jambs, duct, plenum, and casing abutments to building structures.

C. Double-wall ductwork: Install insulation end fittings at all transitions from double to single-wall construction.

3.4 TESTING

A. Interior Duct - Less than 3" WG (positive or negative):

1. Leak testing of these pressure classes is not normally required for interior ductwork (inside the building envelope). However, leak tests will be required if, in the opinion of the Architect/Engineer, the leakage appears excessive. All exterior ductwork shall be tested. If duct has outside wrap, testing shall be done before it is applied.
2. Leak test shall be at the Contractor's expense and shall require capping and sealing all openings.
3. Seal ducts to bring the air leakage into compliance.
4. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing.

B. Interior Duct - 3" WG and Above (positive or negative):

1. A minimum of 25% of interior ductwork (inside the building envelope) shall be tested. The Owner or designated representative shall select the sections to be tested. If duct has outside wrap, testing shall be done before it is applied.

C. Exterior Duct - 1/2□□ WG and Above (positive or negative):

1. All exterior ductwork (outside the building envelope) shall be completely pressure tested. If duct has outside wrap, testing shall be done before it is applied.
2. Leak test shall be at the Contractor's expense and shall require capping and sealing all openings.
3. Seal ducts to bring the air leakage into compliance.
4. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing.

D. Test Procedure:

1. Testing shall be as listed in the latest edition of the SMACNA HVAC Duct Leakage Manual, with the following additional requirements:

    a. The required leakage class for Seal Class A, rectangular ducts, shall be 4; round shall be 2.
    b. Test pressure shall be the specified duct pressure class. Testing at reduced pressures and converting the results mathematically is not acceptable. This is required to test the structural integrity of the duct system.
    c. If any leak causes discernible noise at a distance of 3 feet, that leak shall be eliminated, regardless of whether that section of duct passed the leakage test.
    d. All joints shall be felt by hand, and all discernible leaks shall be sealed.
    e. Totaling leakage from several tested sections and comparing them to the allowable leakage for the entire system is not acceptable. Each section must pass the test individually.
    f. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing. Failure to notify the Architect/Engineer of pressure testing may require the contractor to repeat the duct pressure test after proper notification.
    g. Upon completion of the pressure test, the contractor shall submit an air duct leakage test summary report as outlined in the SMACNA HVAC Duct Leakage Test Manual.
    h. All access doors, taps to terminal air boxes, and other accessories and penetrations must be installed prior to testing. Including terminal air boxes in the test is not required.
    i. Positive pressure leakage testing is acceptable for negative pressure ductwork.

3.5 DUCTWORK PENETRATIONS

A. All duct penetrations of firewalls shall have fire or fire/smoke dampers where required by code.

B. Dampers shall be compatible with fire rating of wall assembly. Verify actual rating of any wall being penetrated with Architect/Engineer.

C. Seal all duct penetrations of walls that are not fire rated by caulking or packing with fiberglass. Install trim strip to cover vacant space and raw construction edges of all openings in finished rooms. Install escutcheon ring at all round duct openings in finished rooms. Trim strips and rings shall be same material and finish as exposed duct.

3.6 DUCTWORK CLEANING

A. General: Applies to existing duct that is to remain.

1. This section applies to the cleaning of ductwork and HVAC system components.
2. The HVAC system cleaning contractor shall be a certified member of the National Air Duct Cleaners Association (NADCA) or shall maintain membership in a nationally recognized non-profit industry organization dedicated to the cleaning of HVAC systems.
3. The HVAC system cleaning contractor shall furnish all necessary equipment, materials, and labor to adequately perform the specified services.
4. The HVAC system cleaning contractor shall be capable of remediation of exposed damaged insulation in air handlers and/or ductwork requiring replacement.
5. Regulatory Requirements:

a. Contractor shall submit to the Owner SDS for all chemical products proposed to be used in the cleaning process.

B. Perform the services specified here in accordance with current NADCA standards.

C. System Component Inspections and Site Preparations:

1. Prior to beginning any cleaning work, perform a visual inspection of the HVAC system to determine appropriate methods, tools, and equipment needed. The cleanliness inspection should include air handling units, other air moving equipment, and ductwork In systems with multiple air handling units, a representative sample of the units should be inspected.
2. Coordinate any system shutdowns with the Owner a minimum of 24 hours in advance of any needed shutdowns.
3. The cleanliness inspection shall be conducted without negatively impacting the indoor environment through excessive disruption of settled dust, microbial amplification, or other debris. .
4. Damaged system components found during the inspection shall be documented and brought to the attention of the Owner and Architect/Engineer.
5. Conduct a site evaluation, and establish a specific, coordinated plan detailing how each area of the building will be protected during each phase of the project.

D. HVAC System Cleaning Requirements:

1. Collect debris removed during cleaning and take precautions to avoid dispersing debris from cleaning operations outside the HVAC system.
2. Use HEPA filters if particulate collection equipment exhausts inside the building.
3. When particulate collection equipment exhausts outside the building, precautions shall be taken to locate the equipment downwind and away from all air intakes and other points of entry into the building.
4. Cleaning operations shall be undertaken only with particulate collection equipment in place, including adequate filtration to contain debris removed from the HVAC system.
5. Take measures to control odors, mist, and vapors during the cleaning process.
6. All HVAC system components must be visibly clean as defined in the NADCA Standards.
7. Volume dampers, control dampers, and other mechanical devices inside the HVAC system must have their positions marked prior to cleaning and, upon completion, must be restored to their marked positions.
8. Service Openings:

a. Use existing service openings where possible.
b. Create openings where needed. Seal openings per the original duct pressure and leakage classification after use.
c. Closures must not significantly restrict or alter the system airflow.
d. Closures must be insulated to prevent heat transfer and condensation.
e. Openings must not compromise the structural integrity of the system.
f. Openings shall conform to applicable NFPA and SMACNA standards, and NADCA Standard 05.
g. Do not cut openings in flexible duct. Disconnect flexible duct at the ends as needed for proper cleaning and inspection.

h. Clearly mark all service openings that can be reopened and mark their locations in the final report.

9. Duct System Cleaning:

a. Create service openings as needed for cleaning inaccessible areas.
b. Mechanically clean all duct systems such that the systems are capable of passing NADCA cleaning verification tests.
c. Seal all openings, grilles, diffusers, etc. in the system to be cleaned.
d. Attach high-pressure vacuum unit to ductwork near fan. Do not exceed the negative pressure rating of ductwork.
e. From farthest opening, work dirt from duct back to extraction point using compressed air, brushes, and scrapers.
f. Do not damage lining or devices during cleaning. Replace any damaged material.

E. Cleaning Methods

1. Source Removal Cleaning Method:

a. Clean the HVAC system using source removal mechanical cleaning methods designed to extract contaminants from the HVAC system and safely remove contaminants from the facility. Select source removal methods that will render the HVAC system visibly clean and capable of passing cleaning verification and other specified tests included in this section. No cleaning method or combination of methods shall be used that could potentially damage the HVAC system or negatively alter the system integrity.
b. Operate vacuum collection devices continuously during cleaning. A vacuum device shall be connected to the downstream end of the section being cleaned. The vacuum collection device must maintain sufficient negative pressure in all areas being cleaned to contain debris and protect the indoor environment.
c. All vacuum devices exhausting air inside the building shall be equipped with HEPA filters, including hand-held vacuums and wet vacuums.
d. All vacuum devices exhausting outside the facility shall be equipped with particulate collection devices including a washable cloth filter bag to contain debris removed from the HVAC system. Such devices shall exhaust in a manner that will not allow contaminants to re-enter the facility. Release of debris outdoors must not violate any codes or regulations.
e. All methods require mechanical agitation devices to dislodge debris adhered to interior HVAC system surfaces such that debris may be safely conveyed to vacuum collection devices. Acceptable methods include those that will not potentially damage the integrity of the ductwork nor damage porous surface materials, such as liners inside the ductwork, or system components.
f. Exterior gas-fired vacuum collection equipment shall be located at least 20 feet away from the building.
g. Where vacuum collection hoses run into the building, the Contractor shall seal the opening airtight so dust from the collection equipment cannot re-enter the building.
h. Hoses for mechanical agitation devices should not enter the building in the same location as the vacuum hoses. Utilize a remote building opening for the tool entry location.

END OF SECTION 23 31 00

SECTION 23 33 00 - DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Manual Volume Dampers.

B. Fire Dampers.

C. Control/Fire/Smoke Dampers.

D. Backdraft Dampers.

E. Fabric Connectors.

F. Drip Pans.

G. Duct Access Doors.

H. Duct Test Holes.

I. Remote Volume Control Devices.

PART 2 - PRODUCTS

2.1 MANUAL VOLUME DAMPERS

A. Fabricate in accordance with SMACNA Duct Construction Standards, and as indicated.

B. Fabricate single blade dampers for duct sizes to 9-1/2 x 30 inches.

C. Fabricate multi-blade damper of opposed blade pattern with maximum blade sizes 12" x 72". Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.

D. Except in round ductwork 12 inches and smaller, provide end bearings. On multiple blade dampers, provide molded synthetic or oil-impregnated nylon or sintered bronze bearings.

E. Provide locking quadrant regulators on single and multi-blade dampers.

F. On insulated ducts, mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

G. If blades are in open position and extend into the main duct, mount damper so blades are parallel to airflow.

2.2 DYNAMIC CURTAIN BLADE FIRE DAMPERS (FD)

A. Furnish and install fire dampers in ducts, where shown on the drawings, at the point where they pass through a fire wall or a floor and in all other locations required by the local fire department, The National Fire Protection Association's Pamphlet No. 90A and all other applicable codes.

B. Fire dampers shall be UL 555 listed for 1-1/2-hour fire resistance unless noted otherwise, dynamic rated with heated airflow at 2,000 fpm and 4" WC, and have all blades stacked out of the airstream (Type B).

C. Where dampers are in aluminum or stainless steel duct, provide stainless steel dampers.

D. Fire dampers shall be held open by a fusible link rated at 165°F unless otherwise called for on the drawings or by local codes.

E. Dampers shall be installed in sleeves of sufficient thickness to comply with the UL555 Standard for Safety Fire Dampers listing of the damper. Where UL555 permits sleeve thickness to be the same as that of the duct gauge, such thickness shall not be less than that specified in NFPA 90A for breakaway style sleeves. If a breakaway style duct/sleeve connection is not used, the sleeve shall be a minimum of 16 gauge for dampers up to 36" wide by 24" high and 14 gauge for dampers exceeding 36" wide by 24" high. Damper sleeve shall not extend more than 6" beyond the firewall or partition unless damper is equipped with a factory installed access door. Sleeve may extend up to 16" beyond the firewall or partition on sides equipped with the factory installed access door.

F. Maximum Curtain Damper Size (Multi-section) at less than 2,000 fpm:

1. Vertical Installation – 72"w x 48"h or 48"w x 72"h or 120"w x 24"h.
2. Horizontal Installation – 36"w x 48"h or 48"w x 36"h.

G. Maximum Curtain Damper Size at greater than 2,000 fpm: Vertical or horizontal - 24"w x 24"h.

H. Locate access door in the ductwork for visual inspection and on the latch side to replace link easily. Each access door shall have a label with letters at least 1/2" high, reading "FIRE DAMPER".

2.3 FIRE/SMOKE DAMPERS (FSD)

A. General:

1. Furnish and install fire/smoke dampers in ducts, where shown on the drawings, at the point where they pass through a fire/smoke partition and in all other locations required by the local Fire Department, the National Fire Protection Association Pamphlet No. 90A, and all other applicable codes.
2. Fire Resistance Rating: Assemblies shall be 1-1/2 hour rated under UL Standard 555 unless noted otherwise on drawings.
3. Airflow Rating: Dynamic rated at 2,000 fpm and 4" WC.
4. Temperature Rating: Assemblies shall be UL 555S listed for use in smoke control system with a 250°F temperature rating.
5. Leakage Rating: Class II. Shall not leak over 20 cfm per square foot at 4" WC.

6. FSD dampers shall be furnished complete with factory-mounted actuators, and the damper/operator assemblies shall meet all requirements listed below.
7. Where dampers are located in aluminum or stainless steel duct, provide stainless steel dampers.
8. The complete assembly must be factory assembled, cycled and tested prior to shipment.
9. All operators shall be located with easy access for servicing.
10. Contractor to field verify actuator installation and clearance requirements prior to ordering. Actuator should not be taller than duct height. Rotate or turn over the actuator if this is the case.

B. Construction:

1. Frame: 5 inches x minimum 16 gauge roll formed, galvanized steel hat-shaped channel, reinforced at corners.
2. Sleeve: Dampers shall be installed in sleeves of sufficient thickness to comply with UL555 Standard for Safety Fire Dampers listing of the damper. Where UL555 permits sleeve thickness to be the same as that of the duct gauge, such thickness shall not be less than that specified in NFPA 90A for breakaway style sleeves. If a breakaway style duct/sleeve connection is not used, the sleeve shall be a minimum of 16 gauge for dampers up to 36" wide by 24" high and 14 gauge for dampers exceeding 36" wide by 24" high. Damper sleeve shall not extend more than 6" beyond the firewall or partition unless damper is equipped with an actuator or factory installed access door. Sleeve may extend up to 16" beyond the firewall or partition on sides equipped with the actuator or factory installed access door.
3. Blades: Opposed blade; airfoil-shaped, single piece, minimum 14 gauge double skin. Galvanized steel. Maximum 6" damper blades.
4. Seals: Blade seal shall be silicone fiberglass material to maintain smoke leakage rating to minimum of 450°F and galvanized steel for flame seal to 1,900°F. Seal to be mechanically attached to blade edge. Jam seal shall be stainless steel, flexible metal compression type.
5. Bearings: Self-lubricating stainless-steel sleeve, in extruded hole in frame.
6. Axle: Minimum 1/2" plated steel, hex shaped, mechanically attached to blade.

C. Electric Actuator: Externally mounted, electric direct coupled. Actuator shall be 24VAC. Wiring by Mechanical Contractor. "Stall type" actuators are NOT acceptable. Actuator shall carry a manufacturer¢¢s 5 year warranty. Fail to closed position.

2.4 BACKDRAFT DAMPERS

A. Gravity backdraft dampers, size 18 inches x 18 inches or smaller, furnished with air moving equipment, may be air moving equipment manufacturer's standard construction.

B. Fabricate multi-blade, parallel action gravity balanced backdraft dampers of extruded aluminum, with blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90° stop, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

C. Models:

1. Ruskin CBD4
2. Arrow 655

3. Safe-Air/Dowco BRL
4. Greenheck EM.

2.5 FABRIC CONNECTORS

A. Fabric connectors shall be installed between all fans or fan units and metal ducts or casings to prevent transfer of fan or motor vibration.

B. The fabric connectors shall be completely flexible material which shall be in folds and not drawn tight.

C. Fabric connectors shall be of glass fabric double coated with neoprene, with UL approval. Weight = 30 oz. per square yard minimum. Fabric shall not be affected by mildew and shall be absolutely waterproof, airtight and resistant to acids, alkalis, grease and gasoline, and shall be noncombustible.

D. Fabric connections shall not exceed 6" in length on ductwork that has a positive pressure. On ductwork that has a negative pressure, the length shall not exceed 2" in length.

E. All corners shall be folded, sealed with mastic and stapled on 1" centers.

F. Fabric connectors shall not be painted.

G. Unless otherwise shown on the drawings, the fabric connection at the inlet to centrifugal fans shall be at least one duct diameter from the fan to prevent inlet turbulence.

H. Materials:

1. Durodyne MFN-4-100
2. Vent Fabrics, Inc.
3. "Ventglas"
4. Proflex PFC3NGA

I. Fabric connectors exposed to sunlight and weather shall be as described above, except the coating shall be hypalon in lieu of neoprene.

J. Materials:

1. Durodyne "Duralon MFD-4-100"
2. Vent Fabrics, Inc.
3. "Ventlon"
4. Proflex PFC3HGA

2.6 DRIP PANS

A. Install drip pans under all rooftop exhaust fans, intake hoods, exhaust hoods and other roof penetrations that do not have ductwork below them to intercept dripping water.

B. Drip pans shall be 22 gauge minimum cross-broken or reinforced sheet metal with 2" welded upturned lips.

C. Pans shall extend 6" in all directions beyond the opening and shall have the top of the lip located 25% of the maximum throat dimension below the opening.

D. Insulate interior of drip pan with 1" thick elastomeric foam insulation. Adhere foam to drip pan with standard foam adhesive.

2.7 DUCT ACCESS DOORS

A. Fabricate per Fig. 7-2 and 7-3 of the SMACNA HVAC Duct Construction Standards and as indicated.

B. Review locations prior to fabrication. Install access doors at fire dampers, smoke dampers, motorized dampers, fan bearings, filters, automatic controls, humidifiers, louvers, duct coils and other equipment requiring service inside the duct.

C. Provide duct access door in all horizontal return ductwork at 20 foot intervals per NFPA 90A.

D. Construction shall be suitable for the pressure class of the duct. Fabricate rigid, airtight, and close-fitting doors of materials identical to adjacent ductwork with sealing gaskets butt or piano hinges, and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover.

E. Access doors with sheet metal screw fasteners are not acceptable.

F. Minimum size for access doors shall be 24" x 16" or full duct size, whichever is less.

G. Provide quantity of access doors such that two hands can fit inside ductwork to manually reset fire dampers. This will typically require one access door on the bottom and one access door on an accessible side of the duct for sizes 12x12 and smaller.

2.8 DUCT TEST HOLES

A. Cut or drill temporary test holes in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

2.9 REMOTE VOLUME CONTROL DEVICES - MANUAL

A. Remote volume control balancing damper shall be supplied with either miter gears or right angle worm gears. Provide all damper shafts, gearboxes, couplings, U-joints, bearings, shafts, offsets, adapters, and adjustable concealed covers as required.

B. When distances, angles, or offsets prevent installing solid rods, the mechanical cable control system may be utilized. Provide all damper shafts, rack and pinion gear operator, cables and sleeves, and adjustable ceiling mounting cups.

2.10 DUCTWORK ACCESSORY SEALANTS

A. Ductwork accessory sealants and adhesives shall conform to Section 23 31 00.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install accessories in accordance with manufacturer's instructions.
2. Where duct access doors are located above inaccessible ceilings, provide ceiling access doors. Coordinate location with the Architect/Engineer.
3. Coordinate and install access doors provided by others.
4. Provide access doors for all equipment requiring maintenance or adjustment above an inaccessible ceiling. Minimum size shall be 24" x 24".
5. Provide duct test holes where indicated and as required for testing and balancing purposes.

B. Manual Volume Damper:

1. Provide manual volume dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts where indicated on drawings and as required for air balancing. Use splitter dampers only where indicated.
2. Provide ceiling access doors for manual volume dampers. When manual volume dampers are located above an inaccessible ceiling and an access door cannot be installed, provide a remote-controlled volume control device for operation of the damper. Coordinate location with the Architect/Engineer.

C. Fire Damper, Fire Smoke Damper:

1. Provide fire dampers, combination fire and smoke dampers, and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves and duct connections.
2. Provide ceiling access doors for smoke and/or fire dampers. Coordinate location with the Architect/Engineer.
3. Demonstrate resetting of fire dampers to authorities having jurisdiction and Owner's representative.
4. At fire dampers, combination fire smoke dampers where duct is:

    a. Internally insulated, exterior duct wrap shall be installed from the wall out to 1 foot from the wall. All edges shall be taped.
    b. Externally insulated, the exterior duct wrap shall extend up to the wall.

D. Drain Pan:

1. Drain pans shall be installed per ASHRAE 62.1.

    a. All drain pans shall be field tested under normal operating conditions to ensure proper drainage.

b. Field testing of drain pans is not required if units with factory installed drain pans have been certified (attested in writing) by the manufacturer for proper operation when installed as recommended.

END OF SECTION 23 33 00

SECTION 23 34 23 - POWER VENTILATORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Roof Exhaust Fan.

B. Rooftop Fan Curbs.

1.2 QUALITY ASSURANCE

A. Performance Ratings: Conform to AMCA 210 and bear AMCA Certified Rating Seal.

B. Sound Ratings: AMCA 301, tested to AMCA 300.

C. Fabrication: Conform to AMCA 99.

D. Fan Energy Index (FEI): Fans shall meet or exceed the minimum FEI scheduled at the specified airflow, pressure, and air density (duty point). In no case shall the FEI at the specified duty point fall below 1.0.

1.3 SUBMITTALS

A. Submit shop drawings per Section 23 05 00. Include data on all fans and accessories. Submit sound power levels for both fan inlet and outlet at rated capacity. Submit motor ratings and electrical characteristics, plus motor and electrical accessories. Submit multi-speed fan curves including minimum and maximum fan speed with specified operating points clearly plotted. Submit the Fan Energy Index (FEI) at the selected duty point (ceiling and HVLS fans are exempt from FEI submittal requirements).

B. Submit manufacturer's installation instructions.

C. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

PART 2 - PRODUCTS

2.1 ROOFTOP EXHAUST FAN - BELT DRIVEN

A. Fan Wheel: Centrifugal type, aluminum hub and wheel with backward inclined blades, statically and dynamically balanced.

B. Housing: Removable, spun aluminum dome or rectangular top, with square, one piece, aluminum base and curb cap with Venturi inlet cone.

C. Fan Shaft: Turned, ground and polished steel; keyed to wheel hub.

D. All steel parts galvanized or epoxy coated. Non-corrosive fasteners.

E. V-belt drive with adjustable pitch drive sheave and adjustable motor mountings for belt tensioning.

F. Motor mounted outside of air stream and ventilated with outside air.

G. Aluminum or brass bird screen. Plastic mesh will not be allowed.

H. Furnish factory mounted and wired disconnect switch: Non-fusible type with thermal overload protection mounted inside fan housing, factory wired through an aluminum conduit.

I. Furnish normally closed, electric motorized damper. Provide step down transformer if required. Install and wire damper to open when fan runs.

J. Dampers shall be aluminum with brass bushings, blade seals and blade tie rods. Leakage shall not exceed 4 cfm/sq.ft @1" SP (or shall be AMCA Class 1 certified).

K. Mill aluminum finish.

L. Permanently lubricated, permanently sealed, self-aligning ball bearings.

M. Furnish permanently lubricated sealed ball type motor and drive shaft bearings sized for 200,000 hours life at specified operating conditions. Drives sized for 150% of rated motor horsepower. Drive assembly and wheel supported by vibration isolators.

N. Manufacturers:

1. Aerovent "FACX"
2. Cook "ACE-B"
3. Greenheck "GB"
4. Carnes "VEB"
5. PennBarry DX
6. ACME PV
7. ILG CRB
8. Twin City BCRD

2.2 ROOFTOP EXHAUST FAN - DIRECT DRIVEN

A. Fan Wheel: Centrifugal type, aluminum or composite with backward inclined or airfoil blades, statically and dynamically balanced.

B. Housing: Removable, spun aluminum dome or rectangular top, with square, one piece, aluminum base and curb cap with Venturi inlet cone.

C. Fan Shaft: Turned, ground and polished steel; keyed to wheel hub.

D. All steel parts galvanized or epoxy coated. Non-corrosive fasteners.

E. Direct drive, motor mounted outside of air stream and ventilated with outside air.

F. Aluminum or brass bird screen. Plastic mesh will not be allowed.

G. Furnish factory mounted and wired disconnect switch: Non-fusible type with thermal overload protection mounted inside fan housing, factory wired through an aluminum conduit.

H. Furnish solid-state dial speed controller. Mount and wire inside fan unless shown otherwise on the drawings. Provide permanent marking at balanced point.

I. Furnish normally closed, electric motorized damper. Provide step-down transformer if required. Install and wire damper to open when fan runs.

J. Dampers shall be aluminum with brass bushings, blade seals and blade tie rods. Leakage shall not exceed 4 cfm/sq.ft @1" SP (or shall be AMCA Class 1 certified).

K. Mill aluminum finish.

L. Furnish permanently lubricated sealed ball type motor and drive shaft bearings. Motor and wheel supported by vibration isolators.

M. Manufacturers:

1. Aerovent "FACX"
2. Cook "ACE-D"
3. Greenheck
4. ILG - CRD
5. ACME PX
6. PennBarry DX
7. Carnes
8. Twin City DCRU
9. Soler-Palau

2.3 ROOFTOP FAN CURBS

A. Furnish and install prefabricated roof curbs for all rooftop fans.

B. Size curb to match the curb cap of fan.

C. Roof Mounting Curb: Minimum 14 inches, minimum 14 gauge galvanized steel, one-piece construction, insulated, all welded, wood nailer.

D. Unitized construction, continuous arc welded corner seams. Insulated with 1-1/2" thick, 3 lb. density rigid fiberglass board. Damper support angle. Pressure treated wood nailer.

E. If called for in the drawings, curbs shall be of the sound attenuation type. Sound attenuation curbs shall reduce the fan sone rating by at least 40% and not decrease fan cfm more than 8% (which is accounted for in the scheduled fan cfm). Baffles shall be removable for access to the dampers.

F. 14-gauge aluminum construction.

G. Curb without cant.

H. Manufacturers:

1. Same manufacturer as the fan
2. Pate
3. RPS
4. Thy

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Secure roof exhausters with cadmium plated lag screws to roof curb.

C. If manufacturer has no recommendations, secure roof exhaust fans to curbs with 1/4" lag bolts on 8" maximum centers.

D. MC shall install and wire factory provided damper to open when the fan runs if the manufacturer does not provide an option to pre-wire the damper.

END OF SECTION 23 34 23

SECTION 23 36 00 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Single Duct Variable Air Volume Terminal Box.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00.

B. Submit shop drawings indicating configuration, general assembly, and materials used in fabrication.

C. Submit product data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings which indicate airflow, static pressure, and NC designation.

D. Include schedules listing discharge and radiated sound power level for each of second through sixth octave bands at inlet static pressures of one to 4 inch WG.

E. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

F. Submit manufacturer's installation instructions.

1.3 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists.

C. Include directions for resetting constant volume regulators.

PART 2 - PRODUCTS

2.1 ACOUSTICAL CONSIDERATIONS (THIS APPLIES TO ALL UNITS)

A. All units shall have noise data certified in accordance with AHRI Standard 885-98 with 5/8" 20-lb. density mineral fiber ceiling tile and shall not produce space noise values over NC-35 due to radiated and airborne noise combined. Acoustical considerations shall take priority over sizes noted in schedule. It is the manufacturer’s responsibility to increase inlet size to meet acoustic levels scheduled. Noise in classrooms shall not exceed 35 dBA or 55 dBC per ANSI Standard S12.60-2002.

2.2 SINGLE DUCT VARIABLE AIR VOLUME TERMINAL BOX

A. Casing: Minimum 22 gauge galvanized steel.

1. Fully insulated with 3/4" elastomeric closed cell insulation liner. Insulation shall be UL listed and meet NFPA 90A requirements.

B. Damper Blade: Extruded aluminum or minimum 18 gauge galvanized steel. Nylon or bronze bushings on damper shafts. Dampers shall seal against gasketed stops. Leakage shall not exceed 4% of unit nominal cfm at 3.0 inches WG inlet static pressure.

C. Inlet Flow Sensor: Provide "cross" □□or "ring□□" style velocity and static sensor at inlet to box for use by unit controller.

D. Damper Operators: Electronic. Furnish all mounting brackets, relays, and linkages. Provided and installed by the manufacturer.

1. Operator shall be UL listed, electronic direct coupled with spring return to normal position for modulating or two-position control as noted in the sequence of control. Actuator shall be 24 VAC with proportional control, electronic overload protection to prevent actuator damage due to over-rotation and "V" bolt clamp with matching "V" toothed cradle (single bolt or setscrew fasteners not acceptable).

E. Electronic Volume Regulator/Controller: Provided and installed by the manufacturer. Boxes shall have pressure independent control to maintain constant air volume regardless of duct pressure changes up to 6 inches w.c. and shall be accurate down to 0.004" velocity pressure. Set boxes for maximum and minimum settings shown on the drawings.

F. Hot Water Coils: Copper tubes, aluminum fins, minimum 0.016" wall thickness, leak tested at 300 psig. Air pressure drop shall not exceed scheduled value. Provide access door or removable panel for access to the upstream side of the heating coil. Capacity shall be as scheduled on the drawings. Hot water control valve shall be by the TCC.

G. Electric Heating Coil: Open nichrome type electric resistance coils, automatic reset thermal cutout primary safety device, manual reset thermal cutout secondary safety device, airflow switch interlock, disconnect switch on face of integral control panel, magnetic contactors, 24-volt control, control voltage transformer and fusing, SCR control. Capacity and voltage shall be as scheduled on the drawings.

H. Boxes shall not exceed the static pressure drop and N.C. level scheduled on the drawings. It is the manufacturer's responsibility to increase inlet size to meet pressure drop and N.C. levels scheduled.

I. Refer to control diagrams and notes on control drawings for complete sequence of control.

J. Manufacturers:

1. Carrier
2. Titus
3. Trane
4. Krueger

5. Carnes
6. E.H. Price
7. Tuttle & Bailey
8. Nailor
9. Enviro-Tec
10. Johnson Controls Inc.
11. Metalaire.
12. Anemostat.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Maintain minimum working clear space for all electrical connections in accordance with NFPA 70, National Electrical Code.

C. Provide ceiling access doors or locate units above easily removable ceiling components.

D. Support units individually from structure. Do not support from adjacent ductwork.

E. Where boxes are located adjacent to a wall or joist, the damper motors and control valves shall be located on the side of the box away from the wall or joist to permit easy access.

F. Comb fins on coils to repair bent fins.

G. Insulate terminal air box hydronic reheat coils to prevent condensation. Tape insulation tight to box. Do not insulate or interfere with actuator, access panel and control panel.

3.2 ADJUSTING

A. All boxes shall be set to the cfm shown on the drawings. TCC shall be responsible to field recalibrate all boxes that are not set correctly.

END OF SECTION 23 36 00

SECTION 23 37 00 - AIR INLETS AND OUTLETS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Grilles And Registers.

B. Architectural Square Panel Diffusers.

C. Linear Diffusers.

D. Linear Diffuser Supply Plenum.

E. Louvers.

1.2 QUALITY ASSURANCE

A. Test and rate performance of air inlets and outlets per ASHRAE 70.

B. Test and rate performance of louvers per AMCA 500L-99.

C. All air handling and distribution equipment mounted outdoors shall be designed to prevent rain intrusion into the airstream when tested at design airflow and with no airflow, using the rain test apparatus described in Section 58 of UL 1995.

1.3 REGULATORY REQUIREMENTS

A. Conform to ANSI/NFPA 90A.

B. Conform to ASHRAE 90.1.

1.4 EXTRA STOCK

A. Provide clean filters in all filter return grilles at time of installation.

B. Provide one additional set of replacement filters for all filter return grilles. Deliver to Owner at job site.

PART 2 - PRODUCTS

2.1 AIR TERMINALS - GRILLES AND REGISTERS

A. Reference to a grille means an air supply, exhaust or transfer device without a damper.

B. Reference to a register means an air supply, exhaust or transfer device with a damper.

C. The type of unit, margin, material, finish, etc., shall be as shown on the drawing schedule and suitable for the intended use.

D. All margins shall be compatible with ceiling types specified (including 'Thin-Line' T-bar lay-in grid system). Any discrepancies in contract documents shall be brought to the attention of the Architect/Engineer, in writing, prior to Bid Date. Submission of Bid indicates ceiling and air inlet and outlet types have been coordinated.

E. The capacity and size of the unit shall be as shown on the drawings.

F. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to 10-12 watts with a 10 dB room effect. Noise in classrooms may not exceed 35 dBA or 55 dBC per ANSI Standard S12.60-2002 and ASHRAE 70.

G. Refer to the drawings for construction material, color and finish, margin style, deflection, and sizes of grilles and registers.

H. Provide with 3/4" blade spacing. Blades shall have steel friction pivots to allow for blade adjustment, plastic pivots are not acceptable.

I. Corners of steel grilles and registers shall be welded and ground smooth before painting. Aluminum grilles and registers shall have staked corners.

J. Where specified to serve registers, provide opposed blade volume dampers operable from the face of the register.

K. Screw holes for surface fasteners shall be countersunk for a neat appearance. Provide concealed fasteners for installation in lay-in ceilings and as specified on the drawings.

L. Manufacturers:

1. Tuttle & Bailey
2. Titus
3. Price
4. Nailor
5. Carnes
6. Metalaire
7. Krueger
8. Anemostat
9. Raymon Donco.

2.2 AIR TERMINALS - ARCHITECTURAL SQUARE PANEL DIFFUSERS

A. Reference to a diffuser means an air supply device, ceiling mounted, that shall diffuse air uniformly throughout the conditioned space.

B. The type of unit, margin, material, finish, etc., shall be as shown on the drawing schedule. Flat-oval inlets are not acceptable for connection to flexible ducts.

C. All margins shall be compatible with ceiling types specified (including 'Thin-Line' T-bar lay-in grid system). Any discrepancies in contract documents should be brought to the attention of the Architect/Engineer, in writing, prior to Bid Date. Submission of Bid indicates ceiling and air inlet and outlet types have been coordinated.

D. The capacity and size of the unit shall be as shown on the drawings.

E. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to 10-12 watts with a 10 dB room effect. Noise in classrooms may not exceed 35 dBA or 55 dBC per ANSI Standard S12.60-2002 and ASHRAE 70.

F. Diffusers shall be architectural solid square panel and flush with ceiling.

G. The exposed surface shall be smooth, flat and free of visible fasteners. The face panel shall be 22 gauge steel with a rolled edge or shall be 18 gauge with a smooth ground, uniform edge.

H. The back pan shall be one piece 22 gauge stamped and shall include an integral inlet. (Welded inlets and corner joints are not acceptable).

I. Diffusers with a 24x24 back pan shall have a minimum 18x18 face panel size. Diffusers with a 12x12 back pan shall have a minimum 9x9 face panel size.

J. The face panel shall be mechanically fastened to the back panel with steel components. (Plastic fasteners are not acceptable.)

K. Manufacturers:

1. Tuttle & Bailey
2. Titus
3. Price
4. Nailor
5. Carnes
6. Metalaire
7. Krueger
8. Anemostat
9. Raymon Donco.

2.3 AIR TERMINALS - LINEAR DIFFUSERS

A. Plenum Slot Diffusers (Lay-In):

1. The type of unit, margin size, material, finish, etc., shall be as shown on the Drawing Schedule. Flat-oval inlets are NOT acceptable for connection to flexible ducts. Provide sheet metal oval-to-round transition if required.
2. The capacity and size of the unit shall be as shown on the drawings.
3. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to 10-12 watts with a 10 dB room effect. Noise in classrooms may not exceed 35 dBA or 55 dBC per ANSI Standard S12.60-2002 and ASHRAE 70.
4. Install T-bars on both sides of diffusers for lay-in ceiling system, install manufacturer frame for sheetrock or plaster ceiling system. Diffuser margins system shall be compatible with ceiling types specified, color to match ceiling system. Contractor shall coordinate margin types with ceilings prior to submitting shop drawings.
5. Linear diffusers and mounting frames shall be furnished as one piece up to 5' in length.
6. Diffusers shall be furnished with factory installed adjustable gasket edged blade deflector.

7. A manual volume damper shall be furnished and installed by the Contractor in branch ductwork to each slot diffuser. Balancing dampers shall not be installed in supply plenum or at air outlet unless otherwise indicated on the drawings.
8. Number and width of slots shall be as shown on the drawings.
9. Provide integral insulated plenum for each linear diffuser. Refer to linear diffuser supply plenum specification section for details.
10. Manufacturers:

    a. Tuttle & Bailey ITPS
    b. Carnes DA
    c. Price TBD
    d. Krueger PTBS
    e. Nailor 5800
    f. Titus TBD
    g. Metalaire
    h. Anemostat API
    i. Raymon Donco SAT.

B. Linear Slot Diffusers (Continuous):

1. The type of unit, margin size, material, finish, etc., shall be as shown on the Drawing Schedule. Flat-oval inlets are NOT acceptable for connection to flexible ducts. Provide sheet metal oval-to-round transition if required.
2. The capacity and size of the unit shall be as shown on the drawings.
3. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to 10-12 watts with a 10 dB room effect. Noise in classrooms may not exceed 35 dBA or 55 dBC per ANSI Standard S12.60-2002 and ASHRAE 70.
4. Install T-bars on both sides of diffusers for lay-in ceiling system, install manufacturer frame for sheetrock or plaster ceiling system. Diffuser margins system shall be compatible with ceiling types specified, color to match ceiling system. Contractor shall coordinate margin types with ceilings prior to submitting shop drawings.
5. Provide with concealed fasteners for installation in the field.
6. Linear diffusers and mounting frames shall be furnished as one piece up to 6' in length. Provide auxiliary support per manufacturer's recommendations for slot diffusers greater than 4' in length.
7. Diffusers shall be furnished with adjustable pattern deflectors capable of providing 180°° pattern adjustment.
8. A manual volume damper shall be furnished and installed by the Contractor in branch ductwork to each slot diffuser. Balancing dampers shall not be installed in supply plenum or at air outlet unless otherwise indicated on the drawings.
9. Number and width of slots shall be as shown on the drawings.
10. Provide insulated plenum for each linear diffuser. Refer to linear diffuser supply plenum specification section for details.
11. Manufacturers:

    a. Tuttle & Bailey 6000/7000
    b. Carnes CH
    c. Price SDS
    d. Krueger 1900
    e. Nailor 5000
    f. Titus ML

g. Anemostat SLAD
h. Raymon Donco HPL
i. Metalaire

2.4 AIR TERMINALS - LINEAR DIFFUSER SUPPLY PLENUM

A. Linear diffusers shall be provided with field fabricated or prefabricated supply plenums. Plenum shall be a minimum of 2-1/2" wider than total slot width, minimum length of slot, and minimum height of 10". Plenums with end fed duct connections shall not exceed 8' in length. The cross sectional area of the plenum shall be designed for a maximum velocity of 500 fpm and the aspect ratio shall be limited to a width-to-height ratio of less than 1.5. Plenums with side outlets shall be designed for a maximum velocity of 600 fpm and inlet ducts to plenum shall be spaced 5' on center maximum. Inlet ducts to plenums shall have a maximum velocity of 900 fpm. Flat-oval inlets are NOT acceptable for connection to flexible ducts. Provide sheet metal oval-to-round transition if required.

2.5 LOUVERS - FIXED - ALUMINUM

A. Louvers shall be minimum 4" deep and constructed of extruded aluminum. Blade, jamb and sill thickness shall be minimum 0.081". Blades shall be spaced at a maximum of 5.1" apart.

B. Louvers shall be of the drainable blade design with water collected on the leading edge of the blade and diverted to the jamb.

C. Louvers shall be furnished with aluminum bird screen mounted on the inside surface.

D. Size, cfm, finish and pressure drop for louvers shall be as scheduled on the drawings.

E. AMCA Certified performance for 48" x 48" samples with intake airflow of 8,000 cfm shall not exhibit more than 0.19" pressure drop. Maximum water penetration shall be 0.01 ounces per square foot at the scheduled intake velocity based on 15 minute test duration when subjected to a water flow rate of 0.25 gal/min as described under the Water Penetration Test in AMCA 500-L-07.

F. Contractor shall provide the General Contractor with the correct sizes and locations of all louvers required in masonry walls.

G. Louvers shall be sealed around perimeter to avoid moisture penetration between the louver frame and wall.

H. Louvers shall be suitable for duct connection.

I. Manufacturers:

1. Air Flow - "EA-403"
2. Arrow - "EA-415-D"
3. American Warming & Ventilating - "LE-21"
4. Construction Specialties - "A4097"
5. Dowco - "DBE-4"
6. Louvers & Dampers, Inc. - "IL-23"
7. Ruskin - "ELF375DX"

8. Vent Products - "2760"
9. Greenheck - ESD "403"
10. Pottorff - EFD

2.6 LOUVERED PENTHOUSES - ALUMINUM

A. Louvers shall be 4" deep and constructed of extruded aluminum. Blade, jamb and sill thickness shall be 0.081". Blades shall be spaced approximately 3" apart.

B. Louvers shall be of the drainable blade design with water collected on the leading edge of the blade and diverted to the jamb.

C. Louvers shall be furnished with aluminum bird screen mounted on the inside surface.

D. Size, cfm, finish and pressure drop for louvers shall be as scheduled on the drawings.

E. Louvers shall be sealed around perimeter to avoid moisture penetration between the louver frame and wall of penthouse.

F. Penthouse structure shall be constructed of an all-welded aluminum.

G. Curb cap shall be of 14 gauge formed aluminum with mitered corners continuously heliarc-welded. Penthouse roof shall be of the same material and cross-broken for added strength. Underside of roof shall be coated with insulating mastic.

H. Corners of penthouse shall be mitered with internal reinforcement.

I. Penthouse and throat shall be reinforced with extruded aluminum angle and have a minimum snow load of 40 lbs. per square foot.

J. Inlet area shall be minimum 150% of throat area for intake hoods. Outlet area shall be minimum 125% of throat area for exhaust hoods and relief vents.

K. Louvered penthouses shall be furnished with 12" high curb (above top of roof) and be of the size and type as shown on the drawings.

L. Manufacturers:

1. Arrow-United
2. American Warming & Ventilating
3. Construction Specialties
4. Dowco
5. Greenheck
6. Louvers & Dampers Inc.
7. Ruskin
8. Vent Products

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install items in accordance with manufacturers' instructions.
2. Check location of inlets and outlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.
3. Install diffusers to ductwork with air tight connections.
4. Flexible ducts shall NOT be joined to flat-oval connections. Provide sheet metal oval-to-round transitions where required.
5. Supply grille and register blades shall be aimed in the field to provide adequate air distribution in the space. All return grilles and registers blades shall be oriented to minimize sight distance beyond installed device.

B. Volume Damper:

1. Provide manual volume dampers on duct take-off to diffusers when there are multiple connections to a common duct. Locate volume dampers as far as possible from the air inlet or outlet.

C. Maintaining Duct Cleanliness:

1. When grilles, registers, and diffusers are installed, Contractor shall prevent construction dust, dirt, and debris from entering ductwork as required by Section 23 05 00.

END OF SECTION 23 37 00

SECTION 23 40 00 - AIR CLEANING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Filters and Filter Media.

1.2 QUALITY ASSURANCE

A. Filter media shall be tested under ANSI/UL 900 and labeled.

B. Provide all filters and filter banks by one manufacturer.

1.3 SUBMITTALS

A. Submit shop drawings per Section 23 05 00. Include data on media, performance, assembly and frames.

1.4 EXTRA STOCK

A. Provide a total of three (3) sets of filters for all units.

1. Provide clean filters in all units at time of installation.
2. Provide clean filters in all units at project final completion after all interior finishes are complete.
3. Provide one additional set of replacement filters for all units. Deliver to Owner at job site.

PART 2 - PRODUCTS

2.1 MERV 4 (FIBERGLASS THROWAWAY) - TYPE B

A. 1" thick fiberglass media with rigid frame and grille, minimum 20% efficiency per ASHRAE Standard 52.1 or MERV 4 per ASHRAE 52.2.

2.2 MERV 4 (FIBERGLASS THROWAWAY) - TYPE C

A. 2" thick fiberglass media with rigid frame and grille, minimum 20% efficiency per ASHRAE Standard 52.1 or MERV 4 per ASHRAE 52.2.

2.3 MERV 8 (MEDIUM EFFICIENCY) - DISPOSABLE - TYPE D

A. Non-woven cotton fabric, pleated media, disposable type with welded wire grid support bonded to the filter media.

B. Heavy duty, paper board frame with diagonal support members bonded to inlet and exit sides of each pleat. Bond frame to media periphery to eliminate air bypass.

C. 4" thick media with at least 4.6 square feet of media per square foot of face area. Maximum initial resistance of 0.30" WGat 500 fpm face velocity.

D. 25-30% efficiency and 90-92% arrestance per ASHRAE 52.1 or MERV 8 per ASHRAE 52.2.

2.4 MERV 11 (65% EFFICIENT) BAG FILTER - TYPE H

A. Disposable type with high density, fine fiber glass media with reinforced backing and galvanized steel face frame.

B. Self-supporting bags without sag under airflow reduced to 25% of the maximum design flow.

2.5 FILTER GAUGES

A. Inclined Manometer: One-piece molded plastic with epoxy coated aluminum scale, inclined-vertical indicating tube and built-in spirit level, 0-2" WG range, 3% of full scale accuracy.

B. Accessories: Static pressure tips with integral compression fittings, 1/4" plastic tubing, 2- or 3-way vent valves, indicating fluid.

C. Manufacturers:

1. Dwyer "Mark II"
2. Meriam Instrument.

D. Differential Pressure Gauge: Diaphragm actuated, nominal 3" round dial, glass filled nylon housing, polycarbonate lens, zero adjustment, 0-2" W.G. range, 5% of full scale accuracy.

E. Accessories: Static pressure tips with integral compression fittings and 1/8" NPT plastic tubing.

F. Manufacturers:

1. Dwyer "Minihelic II" 2-5000
2. Marshalltown Instrument "Series 85C"

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all products per manufacturers' instructions.

B. Seal filter media to prevent passage of unfiltered air around filters with felt, rubber, or neoprene gaskets.

C. Do not operate fan systems without filters.

D. Install static pressure tips upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum, in accessible position. Adjust and calibrate. Every filter bank, including packaged units, shall have a filter gauge.

E. Install four (4) high efficiency filter test holes, two upstream and two downstream, at all high efficiency filter banks in air handling units and ductwork (85% efficiency and higher). Coordinate location of test holes with Owner.

END OF SECTION 23 40 00

SECTION 23 57 00 - HEAT EXCHANGERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Shell and Tube Type Heat Exchangers.

B. Accessories and Trim.

1.2 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 23 05 00. Indicate dimensions, locations, and size of tappings and performance data.

B. Submit manufacturer's installation instructions.

C. Submit design data in sufficient detail to verify that heat exchangers meet or exceed specified requirements.

D. Submit operation and maintenance data. Include start-up and shut down instructions, assembly drawings, and spare parts lists.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Protect internals from entry of foreign material by temporary caps on flanged openings.

1.4 REGULATORY REQUIREMENTS

A. Conform to Section 8D of the ANSI/ASME Boilers and Pressure Vessels Code for manufacture of tubular heat exchangers and heat exchanger shells.

PART 2 - PRODUCTS

2.1 SHELL AND TUBE TYPE HEAT EXCHANGER

A. Tubes: U-tube type with 3/4 inch OD minimum seamless copper tubes suitable for 125 psig working pressure.

B. Shell: Steel with threaded or flanged piping connections and necessary tappings, steel saddle and attaching U-bolts, prime coated.

C. Heads: Cast iron or fabricated steel with steel or bronze tube sheets, threaded or flanged for piping connections.

D. Water Chamber and Tube Bundle: Removable for inspection and cleaning.

E. Design: Heating fluid in shell and heated fluid in tubes.

F. Manufacturers:

1. Bell & Gossett
2. Taco, Amtrol
3. Armstrong Pumps
4. Thrush
5. Grundfos.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install to permit removal of tube bundle with minimum disturbance to installed equipment and piping.

C. Pitch shell to completely drain condensate.

D. Pipe relief valves and drain valves to nearest floor drain.

3.2 STEAM-TO-WATER HEAT EXCHANGER TRIM

A. Shell: Pressure gauge tapping with pigtail siphon, vacuum breaker.

B. Water Inlet: Thermometer well, pressure gauge tapping, valved drain.

C. Water Outlet: Thermometer well for temperature regulator sensor, ASME rated safety relief valve, thermometer well and pressure gauge tappings.

END OF SECTION 23 57 00

SECTION 23 74 16.12 - PACKAGED ROOFTOP AIR CONDITIONING UNITS AND DEDICATED OUTDOOR AIR UNITS - 35 TON AND BELOW

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Packaged Rooftop Unit.

1. Jefferson High School RTU-1, RTU-2, and RTU-3.
2. Brookview Elementary School RTU-1C, RTU-1B, and RTU-2A

B. Unit Controls.

C. Roof Mounting Frame and Base.

1.2 QUALITY ASSURANCE

A. All insulation inside the unit and in the air stream must comply with the requirement of NFPA 90A (maximum flame spread of 25 and maximum smoke developed of 50).

B. All units must be UL or ETL listed and must contain UL labeled components.

C. Fans shall be tested and rated in cabinet in accordance with AMCA Standard 210. All fan assemblies shall be dynamically balanced in cabinet at final assembly.

D. Conform to ASHRAE 90.1.

E. All air handling and distribution equipment mounted outdoors shall be designed to prevent rain intrusion into the airstream when tested at design airflow and with no airflow, using the rain test apparatus described in Section 58 of UL 1995.

1.3 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 23 05 00.

B. Indicate electrical service and duct connections on shop drawings or product data.

C. Submit manufacturer's installation instructions.

D. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

E. Provide 8 octave maximum sound power levels at unit discharge and return connection.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect units from physical damage by storing off site until roof mounting frames are in place, ready for immediate installation of units.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include manufacturer's descriptive literature, installation instructions, maintenance and repair data, and parts listing.

1.6 WARRANTY

A. Provide five (5) year manufacturer's warranty for compressors.

B. Provide five (5) year manufacturer's warranty for heat exchanger.

C. Provide three (3) year manufacturer's warranty for controls and electrical components (thermostats, VFD, etc.).

1.7 MAINTENANCE SERVICE

A. Contractor shall furnish complete service and maintenance of packaged roof top units for one year from Date of Substantial Completion.

B. Provide maintenance service with a two-month interval as maximum time period between calls. Provide 24-hour emergency service on breakdowns and malfunctions.

C. Include maintenance items as outlined in manufacturer's operating and maintenance data, including minimum of four (quarterly) filter replacements, minimum of one fan belt replacement, and controls checkout, seasonal adjustments, and recalibrations.

D. Submit copy of service call work order or report and include description of work performed to Owner and Architect/Engineer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design: The scheduled manufacturer is the Basis of Design. The Contractor is responsible for all costs, schedule impacts, and construction coordination, including design costs and regulatory agency approvals, related to using a specified alternate product other than the Basis of Design. Refer to Section 23 05 00 for additional information.

B. Daikin

C. Trane

D. York

E. Carrier

F. Valent

G. Aaon

2.2 MANUFACTURED UNITS

A. Provide roof-mounted units having electric heat pump capable of heating and cooling and a field installed, hot water duct coil.

B. Unit shall be self-contained, packaged, factory assembled, pre-wired and tested, consisting of cabinet and frame, supply fan, exhaust fan, electric heat pump, controls, air filters, refrigerant cooling coil and compressor, condenser coil, condenser fan, and a full refrigerant charge.

C. Unit shall be furnished with non-fused disconnect switch, short fuse protection of all internal electrical components, and all necessary motor starters, contactors, and over-current protection.

2.3 FABRICATION

A. Cabinet: Galvanized steel with baked enamel finish, access doors or removable access panels with quick fasteners locking door handle type with piano hinges**.** Access doors shall be provided at each section (e.g., filter section, supply fan section, etc.). All exterior access panels must be permanently labeled on the outside indicating what is behind the panel. Structural members shall be minimum 18 gauge, with access doors or removable panels of minimum 20 gauge.

B. Outside Air Intakes: The outside air intakes shall be located a minimum of 15 inches above the roof mounting curb to minimize the effect of heat pickup from the roof during the natural cooling cycle and the effects of snow on the roof during winter operation. Each air intake shall be furnished with rain eliminators.

C. Insulation: Minimum of 1/2" thick, 1.5 lb./cu.ft. density coated glass fiber insulation on surfaces where conditioned air is handled. Protect edges from erosion.

D. Air Filters: Four inch thick MERV 13 glass fiber disposable media in metal frames.

2.4 ROOF MOUNTING FRAME AND BASE

A. Roof Mounting Curb (For units that do not sit on a metal support system by structural): Minimum 24 inches high, minimum 14 gauge galvanized steel, one-piece construction, insulated, all welded, wood nailer.

2.5 FANS/MOTORS

A. Fans:

1. Supply Fans: SWSI plenum fan.
2. Exhaust Fans: Propeller or SWSI plenum fan.
3. All fans shall be aluminum or composite construction with fan shaft: turned, ground and polished steel; keyed to wheel hub.
4. Fan and motor assemblies shall be resiliently mounted.
5. Direct drive motor.
6. All fan bearings must be capable of being lubricated by easily accessible grease fittings.

7. All fans must be statically and dynamically balanced.

B. Motors:

1. Motors shall be open drip-proof with grease lubricated bearings.
2. No equipment shall be selected or operate above 90% of its motor nameplate rating.
3. Motor shall have 1.15 service factor.
4. ECM motors may be provided.

2.6 EVAPORATOR COIL

A. Provide copper tube with aluminum fin coil assembly.

B. Install a drain pan under each cooling coil meeting requirements as outlined in ASHRAE 62.1. The drain pans shall extend the entire width of each coil, including piping and header if in the air stream. The length shall be as necessary to limit water droplet carryover beyond the drain pan to 0.0044oz per ft2 of face area per hour under peak sensible and peak dew point design conditions, considering both latent load and coil face velocity. Pitch drain pans in two directions towards the outlet, with a slope of at least 1/8" per foot.

C. Provide capillary tubes or thermostatic expansion valves for units of 6 tons capacity and less, and thermostatic expansion valves and alternate row circuiting for units 7.5 tons cooling capacity and larger.

D. Provide insulation on liquid refrigerant and suction piping between compressor and evaporator coil where not protected by drain pans. Insulation shall be elastomeric cellular foam; ANSI/ASTM C534; flexible plastic; 0.27 maximum 'K' value at 75°F, 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723). Maximum 1" thick per layer where multiple layers are specified.

2.7 HOT GAS REHEAT COIL

A. Provide copper tube with aluminum fin coil assembly.

B. Valves to reroute hot refrigerant gas from the discharge line of the compressor through the reheat coil.

2.8 COMPRESSOR

A. Provide hermetic or semi-hermetic compressors (quantity as scheduled on drawings), 3600 rev/min maximum, resiliently mounted with positive lubrication, crankcase heater for operation down to 0°F, high and low pressure safety controls, motor overload protection, suction and discharge service valves and gauge ports, and filter drier.

B. Five minute timed off circuit shall delay compressor start.

C. Provide capacity control by providing inverter duty compressors.

D. The use of hydrochlorofluorocarbon (HCFC) or chlorofluorocarbon (CFC) based refrigerants is prohibited.

2.9 CONDENSER

A. Provide copper tube aluminum fin coil assembly with sub-cooling rows.

B. Provide direct drive low noise blade design propeller fans, resiliently mounted with fan guard, motor overload protection, wired to operate with compressor. Fan blade shall be aluminum or composite material.

C. Provide refrigerant pressure switches to cycle condenser fans.

D. Provide hail guards on all condenser coils.

E. Liquid and discharge isolation valves with staged and digital scrolls.

F. Fan motors shall be an ECM type motor for proportional control. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase.

2.10 MIXING SECTION

A. Dampers: Provide remote controlled outside and return air dampers with damper operator and remote rheostat for adjusting outside air quantity.

B. Gaskets: Provide tight fitting dampers with edge gaskets. Gaskets must be mechanically fastened (use of adhesive alone shall not be acceptable). Damper blades shall be gasketed with side seals to provide an air leakage rate of Class 1A at 1" w.c. pressure differential for a 24"x 24" damper. A barometric exhaust damper shall be provided to exhaust air out the back of the unit. A bird screen shall be provided to prevent infiltration of rain and foreign materials. Exhaust damper blades shall be lined with vinyl gasketing on contact edges. Control of the dampers shall be by a factory installed direct coupled actuator.

C. Damper Actuator: 24 volt with gear train sealed in oil, with spring return on units 7.5 tons cooling capacity and larger.

2.11 ELECTRICAL

A. Provide with single point power connection to service all controls, dampers, outlet, and fans, complete with non-fused disconnect switch, short circuit protection of all internal electrical components, and all necessary motor starters, contactors, and over-current protection, transformer, and convenience outlet.

B. All units must be so constructed that when the electrical section access panel is opened, all electrical power to the unit (with the exception of the 120 volt duplex convenience outlet) is disconnected by means of a single disconnect**.**

C. All wiring must be labeled, numbered, and terminate in "spade clips". All terminal strips must be keyed to the wiring numbers. Each control device must be permanently labeled to indicate its function.

D. Wiring diagrams for all circuits must be permanently affixed to the inside of the electrical section access panel. The markings of terminal strips and wiring must agree with the numbering on the wiring diagrams.

E. All units shall include a transformer for controls and convenience outlet.

F. Only one power cable connection to the unit shall be necessary.

G. Motor shall include phase failure protection and prevent the motor from operation in the event of phase loss.

2.12 OPERATING CONTROLS - SINGLE ZONE UNITS

A. When variable speed drives are applied:

1. Single Zone VAV: An electronic variable frequency drive shall be provided for the supply air fan. Each drive shall be factory installed out of the airstream in a conditioned cabinet. Drives shall meet UL Standard 95-5V. The completed unit assembly shall be listed by a recognized safety agency, such as ETL. Drives are to be accessible through a hinged door assembly. Mounting arrangements that expose drives to high temperature unfiltered ambient air are not acceptable.

B. Room thermostat shall incorporate:

1. Automatic switching from heating to cooling.
2. Preferential rate control to minimize overshoot and deviation from set point.
3. Set-up for four separate temperatures per day.
4. Instant override of setpoint for continuous or timed period from one hour to 31 days.
5. Short cycle protection.
6. Programming based on weekdays, Saturday and Sunday.
7. Switch selection features including imperial or metric display, 12 or 24 hour clock, keyboard disable, remote sensor, fan on-auto.

C. Room thermostat display shall include:

1. Time of day.
2. Actual room temperature.
3. Programmed temperature.
4. Programmed time.
5. Duration of timed override.
6. Day of week.
7. System model indication: heating, cooling, auto, off, fan auto, fan on.
8. Stage (heating or cooling) operation.

D. Provide low limit sequence to close outside air dampers and stop supply fan.

E. Mixed Air Controls: Maintain selected supply air temperature and revert dampers to minimum outside air position on a call for heating and above 75°F ambient, when ambient air enthalpy exceeds return air enthalpy.

F. Dehumidification Controls: Maintain the relative humidity setpoint with the hot refrigerant gas reheat coil.

2.13 DDC TEMPERATURE CONTROLS

A. Install standalone control module providing communication between unit controls and packaged DDC temperature control system.

B. Control module shall be compatible with temperature control system specified in Section 23 09 00. Provide BACnet gateway for communication.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that roof is ready to receive work and opening dimensions are as indicated on shop drawings and illustrated by the manufacturer.

B. Verify that proper power supply is available.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Mount units on factory built roof mounting curb and provide watertight enclosure to protect ductwork and utility services. Install unit level.

C. All field wiring shall be in accordance with the National Electrical Code.

D. P-traps must be provided for all drain pans.

E. Comb all coils to repair bent fins.

F. Contractor shall coordinate unit access stair and walkway placement to ensure compliance with OSHA requirements.

3.3 MANUFACTURER'S FIELD SERVICES

A. Provide initial start-up and shutdown during first year of operation.

END OF SECTION 23 74 16.12

SECTION 23 74 16.14 - PACKAGED ROOFTOP AIR CONDITIONING UNITS AND DEDICATED OUTDOOR AIR UNITS WITH ENERGY RECOVERY - GAS/DX

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Packaged Rooftop Unit.

B. Unit Controls.

C. Roof Mounting Frame and Base.

D. Economizers.

E. Heat Recovery.

F. Power Exhaust.

1.2 QUALITY ASSURANCE

A. All insulation inside the unit and in the air stream must comply with the requirement of NFPA 90A (maximum flame spread of 25 and maximum smoke developed of 50).

B. All units must be UL or ETL listed and must contain UL labeled components.

C. Fans shall be tested and rated in cabinet in accordance with AMCA Standard 210. All fan assemblies shall be dynamically balanced in cabinet at final assembly.

D. Conform to ASHRAE 90.1.

E. All air handling and distribution equipment mounted outdoors shall be designed to prevent rain intrusion into the airstream when tested at design airflow and with no airflow, using the rain test apparatus described in Section 58 of UL 1995.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Protect units from physical damage by storing off site until roof mounting frames are in place, ready for immediate installation of units.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include manufacturer's descriptive literature, installation instructions, maintenance and repair data, and parts listing.

1.5 WARRANTY

A. Provide five (5) year manufacturer's warranty for compressors.

B. Provide five (5) year manufacturer's warranty for heat exchanger.

C. Provide three (3) year manufacturer's warranty for controls and electrical components (thermostats, VFD, etc.).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design: The scheduled manufacturer is the Basis of Design. The Contractor is responsible for all costs, schedule impacts, and construction coordination, including design costs and regulatory agency approvals, related to using a specified alternate product other than the Basis of Design. Refer to Section 23 05 00 for additional information.

B. Daikin

C. Trane

D. York

E. Carrier

F. Valent

G. Aaon

2.2 MANUFACTURED UNITS

A. Provide roof-mounted units having gas burner, electric heating elements, and electric refrigeration.

B. Unit shall be self-contained, packaged, factory assembled, pre-wired and tested, consisting of cabinet and frame, supply fan, return fan, exhaust fan, heat exchanger and burner, electric heating elements, controls, air filters, refrigerant cooling coil and compressor, condenser coil, condenser fan, and a full refrigerant charge.

C. Unit shall be furnished with non-fused disconnect switch, short fuse protection of all internal electrical components, and all necessary motor starters, contactors, and over-current protection.

2.3 FABRICATION

A. Cabinet: Galvanized steel with baked enamel finish, access doors with locking door handle with piano hinges. Access doors shall be provided at each section (e.g., filter section, supply fan section, etc.). All exterior access panels must be permanently labeled on the outside indicating what is behind the panel. Structural members shall be minimum 18 gauge, with access doors or removable panels of minimum 20 gauge.

B. Outside Air Intakes: The outside air intakes shall be located a minimum of 15 inches above the roof mounting curb to minimize the effect of heat pickup from the roof during the natural cooling cycle and the effects of snow on the roof during winter operation. Each air intake shall be furnished with rain eliminators.

C. Insulation: All sections shall be double wall, foam injected casings.

D. Heat Exchangers: Stainlesssteel, of welded construction.

E. Air Filters: Four inch thick MERV 13 glass fiber disposable media in metal frames.

F. Heat Recovery: Heat wheel.

2.4 ROOF MOUNTING FRAME

A. Unit Roof Mounting Frame: Provided by structural contractor, refer to structural drawings. Mechanical contractor to provide smaller curbs only around ductwork roof penetrations. Minimum 24 inches (600 mm) high, minimum 14 gauge galvanized steel, one-piece construction, insulated, all welded, wood nailer.

2.5 FANS/MOTORS

A. Fans:

1. Supply Fans: Airfoil centrifugal; SWSI plenum or vane axial fan.
2. Return Fans: Airfoil centrifugal; SWSI plenum or vane axial fan.
3. Exhaust Fans: Airfoil centrifugal; SWSI plenum or vane axial fan.
4. All fans shall be aluminum or composite construction with fan shaft: turned, ground and polished steel; keyed to wheel hub.
5. Fan and motor assemblies shall be resiliently mounted.
6. Direct drive motor.
7. All fan bearings must be capable of being lubricated by easily accessible grease fittings.
8. All fans must be statically and dynamically balanced.

B. Motors:

1. Motors shall be open drip-proof with grease lubricated bearings.
2. Motors shall be "variable frequency drive rated" when controlled by VFDs. Refer to Section 23 05 13.
3. No equipment shall be selected or operate above 90% of its motor nameplate rating.
4. Motor shall have 1.15 service factor.
5. ECM motors may be provided.

2.6 BURNER

A. Gas Burner: Forced draft type burner with adjustable combustion air supply, pressure regulator, gas valves, manual shutoff, intermittent spark or glow coil ignition, flame sensing device, and automatic 100 percent shutoff pilot. Fully modulating gas valve with minimum 10:1 turndown. The burner shall operate efficiently at all firing rates. The burner shall have proven open damper low-high-low pre-purge cycle and proven low fire start. The combustion air control damper shall be in the closed position during the off cycle to reduce losses.

B. Gas Burner Safety Controls: Energize ignition, limit time for establishment of flame, prevent opening of gas valve until pilot flame is proven, stop gas flow on ignition failure, energize blower motor, and after airflow proven and slight delay, allow gas valve to open.

C. High Limit Control: Temperature sensor with fixed stop at maximum permissible setting, de-energize burner on excessive bonnet temperature and energize burner when temperature drops to lower safe value.

D. Supply Fan Control: Temperature sensor sensing bonnet temperatures and independent of burner controls, or adjustable time delay relays with switch for continuous fan operation.

2.7 ELECTRIC HEATING COIL

A. Helical nickel-chrome resistance wire coil heating elements with refractory ceramic support bushings easily accessible with automatic reset thermal cut-out, built-in magnetic contactors, galvanized steel frame, control circuit transformer and fuse, manual reset thermal cut-out, airflow proving device, toggle switch (pilot duty), fused disconnect.

B. Controls shall start supply fan before electric elements are energized and continue operating until air temperature reaches minimum setting, with switch for continuous fan operation.

C. Heating shall have four stages of modulating SCR control.

2.8 EVAPORATOR COIL

A. Provide copper tube with aluminum fin coil assembly.

B. Install a drain pan under each cooling coil meeting requirements as outlined in ASHRAE 62.1. The drain pans shall extend the entire width of each coil, including piping and header if in the air stream. The length shall be as necessary to limit water droplet carryover beyond the drain pan to 0.0044oz per ft2 of face area per hour under peak sensible and peak dew point design conditions, considering both latent load and coil face velocity. Pitch drain pans in two directions towards the outlet, with a slope of at least 1/8" per foot.

C. Provide capillary tubes or thermostatic expansion valves for units of 6 tons capacity and less, and thermostatic expansion valves and alternate row circuiting for units 7.5 tons cooling capacity and larger.

D. Provide insulation on liquid refrigerant and suction piping between compressor and evaporator coil where not protected by drain pans. Insulation shall be elastomeric cellular foam; ANSI/ASTM C534; flexible plastic; 0.27 maximum 'K' value at 75°F, 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723). Maximum 1" thick per layer where multiple layers are specified.

2.9 HOT GAS REHEAT COIL

A. Provide copper tube with aluminum fin coil assembly.

B. Valves to reroute hot refrigerant gas from the discharge line of the compressor through the reheat coil.

2.10 COMPRESSOR

A. Provide hermetic or semi-hermetic compressors (quantity as scheduled on drawings), 3600 rev/min maximum, resiliently mounted with positive lubrication, crankcase heater for operation down to 0°F, high and low pressure safety controls, motor overload protection, suction and discharge service valves and gauge ports, and filter drier.

B. Five minute timed off circuit shall delay compressor start.

C. Provide capacity control by providing inverter duty compressors.

D. The use of hydrochlorofluorocarbon (HCFC) or chlorofluorocarbon (CFC) based refrigerants is prohibited.

2.11 CONDENSER

A. Provide copper tube aluminum fin coil assembly with sub-cooling rows.

B. Provide direct drive low noise blade design propeller fans, resiliently mounted with fan guard, motor overload protection, wired to operate with compressor. Fan blade design shall be a dynamic profile for low tip speed. Fan blade shall be aluminum or composite material.

C. Provide refrigerant pressure switches to cycle condenser fans.

D. Provide hail guards on all condenser coils.

E. Liquid and discharge isolation valves with staged and digital scrolls.

F. Fan motors shall be an ECM type motor for proportional control. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase.

2.12 MIXING SECTION

A. Dampers: (May be omitted from DOAS units) Provide outside, return, and relief dampers with damper operator and control package to automatically vary outside air quantity. Outside air damper shall fail to closed position. Relief dampers may be gravity balanced.

B. Gaskets: Provide tight fitting dampers with edge gaskets. Gaskets must be mechanically fastened (use of adhesive alone shall not be acceptable). Damper blades shall be gasketed with side seals to provide an air leakage rate of Class 1A at 1" w.c. pressure differential for a 24"x 24" damper. A barometric exhaust damper shall be provided to exhaust air out the back of the unit. A bird screen shall be provided to prevent infiltration of rain and foreign materials. Exhaust damper blades shall be lined with vinyl gasketing on contact edges. Control of the dampers shall be by a factory installed direct coupled actuator.

C. Damper Actuator: 24 volt with gear train sealed in oil, with spring return on units 7.5 tons cooling capacity and larger.

2.13 ECONOMIZERS

A. Factory installed by approved rooftop unit manufacturer with fully modulating motorized outside air and return air dampers.

B. To be controlled by differential enthalpy with fixed dry-bulb controller with minimum position setting.

C. Shall be capable of introducing up to 100% outside air.

D. Shall maintain minimum airflow into the building during occupied period and provide design ventilation rate for full occupancy.

E. Dampers shall be capable of completely closing when unit is in unoccupied mode.

F. Outside air damper normally closed and return air damper normally open.

G. Provide factory installed and tested, outdoor air monitor that controls outdoor air ± 15% accuracy down to 40 cfm per ton.

H. Economizer Fault Detection and Diagnostics (FDD):

1. Air-cooled unitary direct-expansion units that are equipped with an economizer shall include a fault detection and diagnostics system complying with the following:

a. The following temperature sensors shall be permanently installed to monitor system operation:

1) Outside air.
2) Supply air.
3) Return air.

b. Temperature sensors shall have an accuracy of ±2°F over the range of 40°F to 80°F.
c. Refrigerant pressure sensors, where used, shall have an accuracy of ± 3 percent of full scale.
d. The unit controller shall be configured to provide system status by indicating the following:

1) Free cooling available.
2) Economizer enabled.
3) Compressor enabled.
4) Heating enabled.
5) Mixed air low limit cycle active.
6) The current value of each sensor.

e. The unit controller shall be capable of manually initiating each operating mode so that the operation of compressors, economizers, fans, and the heating system can be independently tested and verified.
f. The fault detection and diagnostics system shall be configured to detect the following faults:

1) Air temperature sensor failure/fault.
2) Not economizing when the unit should be economizing.
3) Economizing when the unit should not be economizing.
4) Damper not modulating.
5) Excess outdoor air.

g. The unit shall be configured to report faults to a fault management application available for access by day-to-day operating or service personnel or annunciated locally on zone thermostats.

2.14 HEAT RECOVERY

A. Heat Wheel:

1. Heat Recovery Device: Heat Wheel - Aluminum Substrate with 4 Angstrom Molecular Sieve Desiccant:

a. Energy recovery shall be an integral part of unit from the manufacturer. No field assembly, ducting, or wiring shall be required with the energy recovery option.
b. Energy recovery media shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with quarter-turn latches.
c. Energy recovery shall be provided through a total enthalpy wheel providing sensible and latent energy transfer per the scheduled performance.
d. Energy recovery wheel media shall be constructed of fluted aluminum with permanently-bonded zeolite desiccant.
e. Energy recovery wheel cassette shall be mounted perpendicular (90°) to the base of the unit.
f. A VFD shall be required to modulate the speed of the wheel and to provide soft start to extend the life of the belt.
g. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours.
h. Rotor media shall be reinforced using aluminum structural spokes with extruded central hub and shaft and shall be connected to shaft using pillow bearings.
i. Energy wheel cassette shall include seals, drive motor, and linked drive belt.
j. Latent energy shall be transferred entirely in the vapor phase with no condensation.
k. The energy recovery cassette and wheel drive motor shall be an Underwriters Laboratories recognized component for electrical and fire safety.
l. Thermal performance shall be certified by the wheel manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment.

2. Heat Recovery Device: Heat Wheel - Polymer Substrate with Silica Gel Desiccant:

a. Energy recovery shall be an integral part of unit from the manufacturer. No field assembly, ducting, or wiring shall be required with the energy recovery option.
b. Energy recovery media shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with quarter-turn latches.
c. Energy recovery shall be provided through a total enthalpy wheel providing sensible and latent energy transfer per the scheduled performance.
d. Energy recovery wheel shall be constructed of lightweight polymer substrate with permanently-bonded silica gel desiccant.

e. Energy recovery wheel cassette shall be mounted perpendicular (90°) to the base of the unit.
f. A VFD shall be required to modulate the speed of the wheel and to provide soft start to extend the life of the belt.
g. Individual pie-shaped wheel sections shall be removable from wheel cassette for maintenance.
h. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours.
i. Rim shall be continuous rolled stainless steel, and the wheel shall be connected to the shaft by means of taper locks.
j. Energy wheel cassette shall include seals, drive motor, and urethane drive belt.
k. Latent energy shall be transferred entirely in the vapor phase with no condensation.
l. The energy recovery cassette and wheel drive motor shall be an Underwriters Laboratories recognized component for electrical and fire safety.
m. Thermal performance shall be certified by the wheel manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment.

2.15 POWER EXHAUST

A. Factory installed by economizer supplier or compatible equivalent.

B. Controlled by economizer controls.

C. Power exhaust shall be factory wired to electrical section complete with conduit, feeders, disconnect, and overcurrent protection. Power exhaust shall be energized based on building pressure or when dampers open past the adjustable setpoint of the economizer control.

D. Must comply with Energy Code Fan Power Limitation formula.

E. Fans:

1. Exhaust Fans: Propeller or SWSI plenum fan.
2. All fans shall be aluminum or composite construction with fan shaft: turned, ground and polished steel; keyed to wheel hub.
3. Fan and motor assemblies shall be resiliently mounted.
4. Direct drive motor or with V-belt drive and rubber isolated hinge mounted motor.
5. All fan bearings must be capable of being lubricated by easily accessible grease fittings.
6. All fans must be statically and dynamically balanced.

F. Motors:

1. Motors shall be open drip-proof with grease lubricated bearings.
2. Motors shall be "variable frequency drive rated" when controlled by VFDs. Refer to Section 23 05 13.
3. No equipment shall be selected or operate above 90% of its motor nameplate rating.
4. Motor shall have 1.15 service factor.
5. ECM motors may be provided.

2.16 ELECTRICAL

A. Provide with single point power connection to service all controls, dampers, outlet, and fans, complete with non-fused disconnect switch, short circuit protection of all internal electrical components, and all necessary motor starters, contactors, and over-current protection, transformer, and convenience outlet.

B. All units must be so constructed that when the electrical section access panel is opened, all electrical power to the unit (with the exception of the 120 volt duplex convenience outlet) is disconnected by means of a single disconnect**.**

C. All wiring must be labeled, numbered, and terminate in "spade clips". All terminal strips must be keyed to the wiring numbers. Each control device must be permanently labeled to indicate its function.

D. Wiring diagrams for all circuits must be permanently affixed to the inside of the electrical section access panel. The markings of terminal strips and wiring must agree with the numbering on the wiring diagrams.

E. All units shall include a transformer for controls and convenience outlet.

F. Only one power cable connection to the unit shall be necessary.

G. Motor shall include phase failure protection and prevent the motor from operation in the event of phase loss.

2.17 OPERATING CONTROLS - SINGLE ZONE UNITS

A. Provide low limit sequence to close outside air dampers and stop supply fan.

B. Dehumidification Controls: Maintain the relative humidity setpoint with the hot refrigerant gas reheat coil.

2.18 DDC TEMPERATURE CONTROLS

A. Install standalone control module providing communication between unit controls and packaged DDC temperature control system.

B. Control module shall be compatible with temperature control system specified in Section 23 09 00. Provide BACnet gateway for communication.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that roof is ready to receive work and opening dimensions are as indicated on shop drawings and illustrated by the manufacturer.

B. Verify that proper power supply is available.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Mount units on factory built roof mounting curb and provide watertight enclosure to protect ductwork and utility services. Install unit level.

C. All field wiring shall be in accordance with the National Electrical Code.

D. P-traps must be provided for all drain pans.

E. Comb all coils to repair bent fins.

F. Contractor shall coordinate unit access stair and walkway placement to ensure compliance with OSHA requirements.

3.3 MANUFACTURER'S FIELD SERVICES

A. Provide initial start-up and shutdown during first year of operation.

END OF SECTION 23 74 16.14

SECTION 23 81 26 - SPLIT SYSTEM AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Split system air conditioning units.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00.

B. Indicate drain, electrical, and refrigeration rough-in connections on shop drawings or product data.

C. Submit manufacturer's installation instructions.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Accept units and components on site in factory protective containers, with factory shipping skids and lifting lugs. Inspect for damage.

B. Comply with manufacturer's installation instruction for rigging, unloading, and transporting units.

C. Protect units from weather and construction traffic by storing in dry, roofed location until units are ready for immediate installation.

1.4 REGULATORY REQUIREMENTS

A. Conform to ANSI/NFPA 90A for the installation of computer room air conditioning units.

B. Conform to ASHRAE 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include manufacturer's descriptive literature, operating instructions, installation instructions, and maintenance and repair data.

1.6 WARRANTY

A. Provide five (5) year manufacturer's warranty on all compressors.

PART 2 - PRODUCTS

2.1 SPLIT SYSTEM WALL MOUNTED UNITS

A. Manufacturers:

1. Carrier/Toshiba
2. LG
3. Panasonic/Sanyo
4. Samsung
5. Daikin Applied
6. Trane/Mitsubishi
7. York/Hitachi
8. Lennox

B. Manufactured Units:

1. Provide packaged, air-cooled, factory assembled, pre-wired and pre-piped unit consisting of cabinet, fans, filters, remote condensing unit, and controls. Wall-mounted units shall be furnished with integral wall mounting bracket and mounting hardware.
2. Assemble unit for wall-mounted or ceiling installation with service access required.
3. Performance shall be as scheduled on the drawings.
4. Unit shall be rated per AHRI Standards 210/240 and listed in the AHRI directory as a matched system.
5. Provide unit with factory-supplied cleanable air filters.
6. The units shall be listed by Electrical Laboratories (ETL) in accordance with UL-1995 certification and bear the ETL label.
7. All wiring shall be in accordance with the National Electric Code (NEC).

C. Evaporator Cabinet and Frame:

1. Cabinet:

a. Refer to schedule on drawings for mounting type (wall-mounted).
b. Exposed units shall have a finished appearance with concealed refrigerant piping, condensate drain piping, and wiring connections.

D. Evaporator Fans and Motors:

1. Fans:

a. The evaporator fan shall be direct drive with a single motor having permanently lubricated bearings.
b. The fan shall be statically and dynamically balanced.
c. The indoor fan shall have at least three speeds.

2. Motor:

a. Direct driven, digitally controlled with multiple speeds. Permanently lubricated with internal overload protection.

E. Evaporator Coils (Direct Expansion):

1. Direct expansion cooling coil of seamless copper tubes expanded into aluminum fins.
2. Single refrigeration circuit with externally equalized expansion valve.
3. Coils shall be pressure tested at the factory.
4. A sloped, corrosion-resistant condensate pan with drain shall be provided under the coil.

F. Electrical Panel:

1. Service Connections, Wiring, and Disconnect Requirements: Conform to the National Electrical Code and local electrical codes.

G. Control:

1. The unit shall have a hard-wired 7-day programmable remote controller to operate the system. Provide wall mounting bracket for controller.
2. Remote controller shall have "automatic", "dry" (dehumidification), and "fan only" operating modes.
3. The remote controller shall have the following features:

    a. On/Off power switch.
    b. Mode Selector to operate the system in auto, cool, heat, fan, or dehumidification (dry) operation.
    c. Fan Setting to provide multiple fan speeds.
    d. Swing Louver for adjusting supply louver discharge.
    e. On/Off Timer for automatically switching the unit off or on.
    f. Temperature Adjustment allows for the increase or decrease of the desired temperature.
    g. Powerful Operation to allow quick cool down or heating up in the desired space to achieve maximum desired temperature in the shortest allowable time.

4. The remote controller shall perform fault diagnostic functions that may be system related, indoor or outdoor unit related depending on the fault code.
5. Temperature range on the remote controller shall be 64°F to 90°F in cooling mode and 50°F to 86°F in heating mode.
6. The indoor unit microprocessor shall have the capability to receive and process commands via return air temperature and indoor coil temperature sensors enabled by commands from the remote controller.
7. Integration: Manufacturer shall provide a BACnet interface with the building automation system in accordance with ASHRAE/ANSI Standard 135. This may be accomplished through a system integration panel or "gateway". Integration panels shall be provided as part of the split system.

H. Outdoor Unit:

1. General:

    a. The outdoor unit shall be specifically matched to the corresponding indoor unit size. The outdoor unit shall be completely factory assembled and pre-wired with all necessary electronic and refrigerant controls.

2. Cabinet:

    a. The outdoor unit shall be fabricated of galvanized steel, bonderized and coated with a baked enamel finish for corrosion protection.

3. Fan:

    a. The fan shall be direct drive, propeller type fan with fan guard.
    b. Fan blades shall be statically and dynamically balanced.
    c. The fan shall have permanently lubricated type bearings.
    d. Motor shall be protected by internal thermal overload protection.
    e. Airflow shall be horizontal discharge.

4. Coil:

    a. The outdoor coil shall be nonferrous construction with corrugated fin tube.
    b. The coil shall be protected with an internal guard.
    c. Refrigerant flow from the condenser shall be controlled via a metering device.

5. Compressor:

    a. Hermetic or scroll refrigerant compressors with resilient suspension system, inverter driven, oil strainer, sight glass/moisture indicator, internal motor protection, high pressure switch, and crankcase heater.
    b. The otdoor unit shall have an accumulator and four-way reversing valve.

6. Refrigerant:

    a. Unit shall use R-410a.
    b. The use of chlorofluorocarbon (CFC)-based refrigerants is prohibited.

I. Integral Condensate Pump:

1. Packaged unit matched to evaporator unit including float switch, pump, motor assembly, check valve, and reservoir.
2. Provide alarm to indicate high level reservoir.
3. Unit shall be powered from evaporator unit with appropriate field connections available.

J. Condensate Pump:

2.2 PIPING

A. Design Pressure: 450 psig; Maximum Design Temperature: 250°F

B. Type ACR Seamless Copper Tube Linesets; Brazed Joints:

1. 3/4" and under.
2. Tubing: Type ACR seamless copper tube linesets, ASTM B1003. Sizes indicated are nominal designation.
3. Joints: Brazed with silver solder.
4. Fittings: Wrought copper solder joint, ANSI B16.22.

5. Special Requirements: All tubing shall be cleaned, dehydrated, pressurized with dry nitrogen, plugged, and tagged by manufacturer "for refrigeration service". During brazing operations, continuously purge the interior of the pipe with nitrogen to prevent oxide formation.
6. Limitations:

    a. Only between refrigerant splitter box and indoor terminal unit.

C. Type ACR Hard Drawn Seamless Copper Tube; Brazed Joint:

1. 4" and under.
2. Tubing: Type ACR hard drawn seamless copper tube, ASTM B280. Sizes indicated are nominal designation.
3. Joints: Brazed with silver solder.
4. Fittings: Wrought copper solder joint, ANSI B16.22.
5. Special Requirements: All tubing shall be cleaned, dehydrated, pressurized with dry nitrogen, plugged and tagged by manufacturer "for refrigeration service". During brazing operations, continuously purge the interior of the pipe with nitrogen to prevent oxide formation.

D. Piping - 1-3/8" and Under; Dual Concentric Crimp Mechanical Press Connection (Contractor's Option):

1. Tubing: Type ACR hard drawn seamless copper tube, ASTM B280. Sizes indicated are nominal designation.
2. Joints: Dual concentric crimp band mechanical press connection.
3. Manufacturers:

    a. Parker-Zoomlock
    b. MaxiPro ACR
    c. Nibco ACR Press

E. Refrigerant linesets are not permitted.

1. Provide manufacturer-packaged refrigerant linesets and accessories of sizes needed for installation. Verify lengths of piping required for installation.

2.3 INSULATION

A. EPDM (NBR/PVC Blend is not permitted) elastomeric cellular foam; ANSI/ASTM C534; flexible plastic; 0.25 maximum 'K' value at 75°F, 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723). Minimum 1/2" thick for pipe sizes less than 1-1/4" and 3/4" thick for pipe sizes 1-1/4" and above.

2.4 ROOF MOUNTING CURB

A. Curb height as shown on drawings, minimum 14 gauge galvanized steel, one-piece construction, insulated, all welded, wood nailer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that proper power supply is available.

3.2 INSTALLATION

A. General Installation Requirements:

1. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
2. Install units in accordance with manufacturer's instructions. Install all units level and plumb. Indoor units shall be installed using manufacturer's standard mounting hardware securely fastened to building structure.
3. Refer to Section 23 05 29 for roof support rails for outdoor unit.
4. Coordinate the exact mounting location of all indoor and outdoor units with architectural and electrical work. Coordinate installation of ceiling-mounted units with ceiling grid layout. Provide additional ceiling grid reinforcement or modification as required and coordinate the work with the GC. Locate the indoor unit where it is readily accessible for maintenance and filter changes. Where outdoor units are located on the roof, locate at least 10' from the roof edge.
5. Verify locations of wall-mounted remote controllers with drawings and room details before installation. Coordinate mounting heights to be consistent with other wall-mounted devices. Height above finished floor shall not exceed 48".

B. Condensate Removal:

1. Install condensate piping with trap and route from drain pan to nearest drain. Discharge to nearest code-approved receptor or to a properly vented indirect waste fitting. Flush all piping before making final connections to units.

C. Comb all coils to repair bent fins.

D. Install new filters in the unit at Substantial Completion.

E. A factory-authorized service agent shall assist in commissioning the unit and inspecting the installation prior to startup. Submit startup report with O&M manuals.

3.3 REFRIGERANT PIPING

A. Install refrigerant piping from the indoor unit(s) to the condensing unit. Refrigerant pipe sizes, lengths, specialties and configurations shall be as recommended by the manufacturer. Evacuate refrigerant piping and fully charge system with refrigerant per manufacturer's requirements.

B. Provide weather-tight insulated roof curb to accommodate refrigerant piping and conduit roof penetrations.

C. Insulate all refrigerant piping. Both liquid and suction lines shall be insulated between the indoor and outdoor units.

D. Joining of Piping:

1. Brazed Joints:

a. Make up joints with brazing filler metal conforming to ANSI/AWS A5.8. Cut copper tubing ends perfectly square and remove all burrs inside and outside. Thoroughly clean sockets of fittings and ends of tubing to remove all oxide, dirt, and grease just prior to brazing. Apply flux evenly, but sparingly, to all surfaces to be joined. Brazing filler metal with a flux coating may also be used. Heat joints uniformly to proper brazing temperature so braze filler metal flows to all mated surfaces. Wipe excess braze filler metal, leaving a uniform fillet around cup of fitting.
b. Flux shall conform to ANSI/AWS A5.31.
c. Remove composition discs and all seals during brazing if not suitable for a minimum of 840°For greater than the melting temperature of the brazing filler metal, whichever is greater.

2. Mechanical Press Connection:

a. Copper press fitting shall be made in accordance with the manufacturer's installation instructions.
b. Examination: Upon delivery to the jobsite, examine copper tubing and fittings for debris, defects, incise marks (manufacturer's engraving on tube), holes, or cracks.
c. Fully insert tubing into the fitting and mark tubing.
d. Prior to making connection, the fitting alignment shall be checked against the mark made on the tube to ensure the tubing is fully engaged in the fitting.
e. Joint shall be pressed with a tool approved by the manufacturer.
f. Installers shall be trained by manufacturer personnel or representative. Provide documentation upon request.

E. Insulation:

1. Insulate all refrigerant pipes between the heat pump and indoor units. This includes the liquid pipe, the suction pipe, the hot gas pipe, and the high/low pressure gas pipe. All fittings, valves, and specialty refrigerant components in the piping between the indoor and heat pump units shall also be insulated. The insulation shall have a continuous vapor barrier and shall pass through hangers and supports unbroken. All exterior insulated piping shall be painted with minimum of one (1) coat of UV resistant paint. Over size hangers and supports to allow the insulation to pass through unbroken. Following are the minimum insulation thicknesses unless noted otherwise in the manufacturer's literature or required by local AHJ:
2. ASHRAE 2016:
3. IECC 2018:

a. Refrigerant Suction (40°F & Below):

1) Up to 1": 1/2"
2) 1" and up: 1"

b. Refrigerant Suction (41°F to 60°F):

1) Up to 1-1/2": 1/2"
2) 1-1/2" and up: 1"

c. Refrigerant Low Pressure Gas (141°F-200°F):

1) Up to 1-1/2": 1-1/2"
2) 1-1/2" and up: 2"

d. Refrigerant High Pressure Gas (201°F-250°F):

1) Up to 4": 2-1/2"

e. Refrigerant Liquid:

1) Up to 1-1/2": 1"
2) 1-1/2" and up: 1-1/2"

END OF SECTION 23 81 26

SECTION 23 81 45 - VARIABLE REFRIGERANT FLOW HEAT PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Variable refrigerant flow split system heat pump (heat/cool).

B. Variable refrigerant flow split system heat pump with heat recovery (simultaneous heat/cool).

C. Refrigerant piping/tubing and insulation.

1.2 REFERENCES

A. ANSI/AHRI 210/240 - Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment.

B. ANSI/AHRI 270 - Sound Rating of Outdoor Unitary Equipment.

C. ANSI/ASHRAE 62 - Ventilation for Acceptable Indoor Air Quality.

D. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

E. MIL-H-22547B - Heat Pump, Heating and Cooling (Unitary).

1.3 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 23 05 00.

B. Indicate water, drain, and electrical rough-in connections on shop drawings or product data.

C. Submit manufacturer's installation instructions.

D. Submit manufacturer's warranty information.

E. Submit installing contractor's manufacturer training certification.

F. Submit refrigerant charge. Charge calculation should be based on installed piping lengths and equipment capacities.

G. VRF Piping Layout Drawings:

1. Submit detailed VRF piping layout drawings at 1/8" = 1'-0" minimum scale complete with the following information:

a. Actual pipe routing, fittings, hanger and support types, accessories, etc. with lengths and refrigerant charge noted.
b. Include insulation thickness and type of insulation.

c. Room names and numbers, ceiling types, and ceiling heights.
d. Indicate location of all beams, bar joists, etc., along with bottom of steel elevations, for each member.

2. Submit VRF piping and equipment layout drawings. Verify clearances and interferences with other trades prior to preparing drawings. IMEG will provide electronic copies of piping drawings for Contractor's use if the Contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for this submittal. Submittals shall be in accordance with Section 23 05 00.

H. Submit Electrical Power and Controls Diagrams:

1. Power wiring diagrams for each component.
2. Wiring diagrams and layouts for each control panel showing all termination numbers.
3. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Show all interface wiring to the control system.
4. Schematic diagrams for all field sensors and controllers.
5. A schematic diagram of each controlled system. The schematics shall have all control points labeled. The schematics shall graphically show the location of all control elements in the system.
6. A schematic wiring diagram for each controlled system. Each schematic shall have all elements labeled. Label all terminals.
7. All installation details and any other details required to demonstrate that the system will function properly.
8. All interface requirements with other systems.

I. Sequences: Submit a complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system. **The wording of the control sequences in the submittal shall match verbatim that included in the construction documents to ensure there are no sequence deviations from that intended by the Architect/Engineer. Clearly highlight any deviations from the specified sequences on the submittals.**

J. Control System Demonstration and Acceptance: Provide a description of the proposed process, along with all reports and checklists to be used.

K. Clearly identify work by others in the submittal.

L. Quantities of items submitted may be reviewed but are the responsibility of the Contractor to verify.

M. Manufacturer’s Startup Report: Submit manufacturer’s startup report documenting equipment startup. StartUp report shall include Contractor’s field test reports.

1.4 DELIVERY STORAGE AND HANDLING

A. Protect finished cabinets from physical damage by leaving factory packing cases in place before installation and providing temporary covers after installation.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include manufacturer's descriptive literature, operating instructions, installation instructions, and maintenance and repair data.

1.6 WARRANTY

A. Installing contractor shall perform tasks required by manufacturer to ensure maximum available warranty is achieved. This will include but is not limited to:

1. System design performed by manufacturer certified designer.
2. System installation performed by manufacturer certified installer.
3. Complete system commissioning paperwork and submit to manufacturer.

B. Provide one (1) year manufacturer's warranty on all parts and labor (excluding compressors).

C. Provide minimum five (5) year manufacturer's parts warranty (one-year basic warranty plus four-year extended warranty) on all parts (excluding compressors) and one (1) year labor warranty.

D. Provide minimum ten (10) year manufacturer's parts warranty (one-year basic warranty plus nine-year extended warranty) on all parts (excluding compressors) and one (1) year labor warranty.

E. Provide minimum five (5) year manufacturer's compressor parts warranty.

F. Contractor shall provide one (1) year parts and labor warranty on the associated controls system, including all devices, wiring, and programming.

1.7 DEMONSTRATION

A. Engage manufacturer or factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain individual units and complete system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Daikin AC

B. LG

C. Carrier/Toshiba

D. Trane/Mitsubishi

2.2 SYSTEM DESCRIPTION

A. The variable capacity, heat pump air conditioning system shall be a variable refrigerant flow split system. The system shall consist of multiple evaporators using PID control and inverter driven heat pump unit. The unit shall consist of direct expansion (DX), air-source heat pump air conditioning system, and variable speed driven compressor multi zone split system.

B. Air-Source Heat Pump Unit - General: The heat pump unit is designed specifically for use with the manufacturer's components:

1. Refrigerant: R410A.
2. The air-source heat pump unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant control. The refrigeration circuit of the heat pump unit shall consist of a compressor, motors, fans, condenser coil, electronic expansion valves, oil separators, service ports, liquid receivers, and accumulators.
3. All refrigerant lines shall be individually insulated between the heat pump and indoor units.
4. The connection ratio of the nominal capacity of indoor units to heat pump unit shall be 50-130%.
5. The sound pressure shall be no greater than 63 dBA at 4 feet from the heat pump unit at full load at fan height.
6. The system shall automatically restart operation after a power failure and shall not cause any settings to be lost, thus eliminating the need for re-programming.
7. The following safety devices shall be included on the heat pump unit: high pressure switch, control circuit fuses, crankcase heaters, fusible plug, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers. To ensure the liquid refrigerant does not flash when supplying to the various indoor units, the circuit shall be provided with a sub-cooling feature. Oil recovery cycle shall be automatic as required to maintain oil levels at the heat pump unit.
8. The heat pump unit shall be able to operate in heating mode to -4°F -13°F dry bulb ambient temperature without additional ambient controls.

    a. Heating capacity at design condition of -10°F shall be no less than 100% of the value scheduled on the drawings.

9. The heat pump unit shall have air cooled heat exchange coils constructed from copper tubing with aluminum fins. The coils shall be capable of being divided into sections to enable the heat pump unit to match the capacity required by the indoor units and to allow individual defrosting to take place as required.
10. The heat pump unit shall have at least one inverter controlled compressor, depending on scheduled capacity. The system shall use a control sequence to ensure that indoor loads are matched to the compressor capacity control.
11. The refrigeration process of the heat pump unit will be maintained by pressure and temperature sensors controlling solenoid valves, check valves, and bypass valves. The heating or cooling mode of the heat pump unit will be controlled using a combination of 2 and 3-way valves that shall reverse the cycle of the refrigerant to change the mode of the heat pump unit.
12. Unit Cabinet: The heat pump unit model shall be completely weatherproof and corrosion resistant. The heat pump unit shall be constructed from steel plate and treated with an anti-corrosive paint.Provide hail guards on all condenser coils and fans.

13. Fan:

    a. The heat pump unit shall consist of propeller type, direct-drive fan motors that have multiple speed operation via a DC inverter.
    b. The fans shall be a vertical discharge. The fan motors shall have inherent protection and permanently lubricated bearings.
    c. The fans shall be provided with fan guards.

14. Condenser Coil: The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.
15. Compressor:

    a. The variable speed compressor shall be capable of changing the speed to follow the variations in total cooling load as determined by the suction gas pressure as measured in the heat pump unit.
    b. The inverter driven compressor in each heat pump unit shall be DC, hermetically sealed, scroll type.
    c. The capacity control range shall be a minimum of 20% to 100% of total capacity.
    d. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
    e. Oil separators shall be standard with the equipment, together with an oil balancing circuit.
    f. The compressor shall be mounted to avoid the transmission of vibration.

C. Indoor Units:

1. General – Each indoor unit shall have a heat exchanger that shall be constructed from copper tubing with aluminum fins. The flow of refrigerant through the heat exchanger shall be controlled by an electronic modulating expansion valve. This valve shall be controlled by internal temperature sensors and shall be capable of controlling the variable capacity of the indoor unit between at least 25% and 100%. The units shall be shipped from the factory fully charged with dehydrated air.
2. The indoor units shall be designed for installation within a conditioned space to be connected to an air-source heat pump air conditioning system.
3. Wall Mounted:

    a. Acoustic Performance: The indoor units' sound pressure shall not exceed 35 dBA at low speed measured at 3.3 feet from the units.
    b. Construction:

        1) The indoor units shall be completely factory assembled and tested. Included in each unit is factory wiring, piping, electronic modulating expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. Each unit shall have at least one auto-swing louver for efficient air distribution, which closes automatically when the unit stops. The remote controller shall be able to set five (5) steps of discharge louver angle. The front grille shall be easily removed for washing. The discharge angle shall automatically set at the same angle as the previous operation upon restart. The condensate drain pipe shall be able to be connected to either left or right sides.

c. The indoor units shall be equipped with a return air thermistor.
d. The indoor unit shall be separately powered.
e. Unit Cabinet:

1) The cabinet shall be affixed to a factory supplied wall mounting template and located in the conditioned space.
2) The cabinet shall be constructed of molded plastic cover with sound absorbing foamed polystyrene and polyethylene insulation.

f. Fan:

1) The fan shall be a direct-drive cross-flow type, statically and dynamically balanced with high and low fan speeds available.
2) The fan motor shall be thermally protected.

g. Filter: The return air shall be filtered by means of a washable long-life filter with mildew proof resin.
h. Coils:

1) Coils shall be of the direct expansion type, constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
2) The refrigerant connections shall be flare connections and the condensate shall be coordinated with piping material specified in Section 23 21 00.
3) A condensate pump with at least 18 inches lift shall be located below the coil in the condensate pan, with a built-in high-level safety alarm to shut down the unit.
4) A thermistor shall be located on the liquid and gas line.

4. Four-way Ceiling-Recessed Cassette:

a. The indoor unit shall be a ceiling cassette for installation into the ceiling cavity, equipped with an air panel grille as scheduled and specified in this section. The indoor unit shall have four-way air distribution and an ivory white, impact resistant, washable decoration panel. The supply air shall be distributed via motorized louvers that can be horizontally and vertically adjusted from 0° to 90° angle.
b. Acoustic Performance: The indoor units' sound pressure shall not exceed 33 dBA at low speed measured at 5 feet from the unit.
c. Construction:

1) The indoor unit shall be completely factory assembled and tested. The unit shall include factory wiring, piping, electronic modulating expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, condensate drain pump, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
2) The 4-way supply airflow shall be field modifiable to 3-way and 2-way airflow to accommodate various installation configurations, including corner installations.
3) Return air shall be through the concentric panel, which shall include a filter.
4) The indoor units shall be equipped with a return air thermistor.
5) The indoor unit shall be separately powered.

d. Unit Cabinet:

1) The cabinet shall be space saving and shall be recessed into the ceiling.
2) Provide fresh air intake kit where used and indicated on the drawings. A branch duct knockout shall exist for branch ducting supply air.
3) The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

e. Fan:

1) The fan shall be direct-drive type, with statically and dynamically balanced impeller with high and low fan speeds available.
2) The fan motor shall be thermally protected.

f. Filter: The return air shall be filtered by a washable long-life filter with mildew proof resin.

g. Coil:

1) Coils shall be of the direct expansion type, constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
2) The refrigerant connections shall be flare connections and the condensate shall be coordinated with piping material specified in Section 23 21 00.
3) A condensate pump with at least 18 inches lift shall be located below the coil in the condensate pan, with a built-in high-level safety alarm to shut down the unit.
4) A thermistor shall be located on the liquid and gas line.

5. Ceiling Suspended:

a. The indoor unit shall be a ceiling suspended indoor unit. The unit shall be constructed of galvanized steel with painted finish as scheduled. The indoor unit shall be manufactured for a horizontal discharge air with bottom return air configuration.

b. Acoustic Performance: The indoor units' sound pressure shall range from 22 dB(A) to 31 dB(A) at low speed 5 feet from the unit.

c. Construction:

1) The indoor unit shall be completely factory assembled and tested. The unit shall include factory wiring, piping, electronic modulating expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, condensate drain pump, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall have a booster cable for adjustable static pressure capability.
2) The indoor units shall be equipped with a return air thermistor.
3) The indoor unit shall be separately powered.
4) The switch box shall be reached from the side or bottom for ease of service and maintenance.

d. Unit Cabinet:

1) The cabinet shall be in the ceiling and ducted to the supply and return openings.
2) The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

e. Fan:

1) The fan shall be direct-drive type, with statically and dynamically balanced impeller with high and low fan speeds.
2) The fan motor shall be thermally protected.

f. Filter: The return air shall be filtered by means of a washable long-life filter with mildew proof resin.

g. Coils:

1) Coils shall be of the direct expansion type, constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
2) The refrigerant connections shall be flare connections, and the condensate shall be coordinated with piping material specified in Section 23 21 00.
3) A condensate pump with at least 18 inches of lift shall be located below the coil in the condensate pan, with a built-in high-level safety alarm to shut down the unit.
4) A thermistor shall be located on the liquid and gas line.

6. Floor Standing Exposed:

a. The indoor unit shall be a floor standing exposed indoor unit. The unit shall be constructed of galvanized steel with painted finish as scheduled. The indoor unit shall be manufactured for a vertical discharge air with bottom front return air configuration.

b. Acoustic Performance: The indoor units' sound pressure shall not exceed 31 dBA at low speed 5 feet from the unit.

c. Construction:

1) The indoor unit shall be completely factory assembled and tested. The unit shall include factory wiring, piping, electronic modulating expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall have a booster cable for adjustable static pressure capability.
2) The indoor units shall be equipped with a return air thermistor.
3) The indoor unit shall be separately powered.
4) The switch box shall be reached from the side or bottom for ease of service and maintenance.

d. Unit Cabinet:

1) The cabinet shall be located against the wall, with top mounted supply and bottom return.
2) The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

e. Fan:

1) The fan shall be direct-drive type, with statically and dynamically balanced impeller with high and low fan speeds.
2) The fan motor shall be thermally protected.

f. Filter: The return air shall be filtered by means of a washable long-life filter with mildew proof resin.

g. Coils:

1) Coils shall be of the direct expansion type, constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
2) The refrigerant connections shall be flare connections, and the condensate shall be coordinated with piping material specified in Section 23 21 00.
3) A condensate pump with at least 20 inches of lift shall be located below the coil in the condensate pan, with a built-in high-level safety alarm to shut down the unit.
4) A thermistor shall be located on the liquid and gas line.

2.3 PIPING

A. Design Pressure: 450 psig.

1. Maximum Design Temperature: 250°F.

B. Type ACR Seamless Copper Tube Linesets; Brazed Joints:

1. 1" and under.
2. Tubing: Type ACR seamless copper tube linesets, ASTM B1003. Sizes indicated are nominal designation.
3. Joints: Brazed with silver solder.
4. Fittings: Wrought copper solder joint, ANSI B16.22.
5. Special Requirements: All tubing shall be cleaned, dehydrated, pressurized with dry nitrogen, plugged, and tagged by manufacturer "for refrigeration service". During brazing operations, continuously purge the interior of the pipe with nitrogen to prevent oxide formation.
6. Limitations:
   a. Only sizes 1" and under.
   b. For use above ceiling only. Do not use in exposed areas.

C. Type ACR Hard Drawn Seamless Copper Tube; Brazed Joint:

1. 4" and under.
2. Tubing: Type ACR hard drawn seamless copper tube, ASTM B280. Sizes indicated are nominal designation.
3. Joints: Brazed with silver solder.
4. Fittings: Wrought copper solder joint, ANSI B16.22.
5. Special Requirements: All tubing shall be cleaned, dehydrated, pressurized with dry nitrogen, plugged and tagged by manufacturer "for refrigeration service". During brazing operations, continuously purge the interior of the pipe with nitrogen to prevent oxide formation.

D. Insulation:

1. EPDM (NBR/PVC Blend is not permitted) elastomeric cellular foam; ANSI/ASTM C534; flexible plastic; 0.25 maximum 'K' value at 75°F, 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723). If thickness required in Part 4 - Execution does not meet 25/50 flame spread/smoke developed rating, use multiple layers of a thickness that does meet 25/50 flame spread/smoke developed.

2.4 CONTROLS GENERAL

A. The unit shall have controls provided with the unit by the manufacturer to perform input functions necessary to operate the system.

B. Computerized PID control shall be used to maintain room temperature within 1°F of setpoint.

C. The unit shall be equipped with a programmable drying cycle that dehumidifies while inhibiting changes in room temperature.

D. The indoor circuit board shall be wired to enable auxiliary heating when at least one of the following occurs:

1. Coil thermistor temperature drops below a factory setpoint in heating mode.
2. Heat pump temperature drops below setpoint (adj.).
3. Based on a user adjustable schedule.

2.5 SYSTEM CONTROLLER - TYPE C

A. The controller shall control at least 50 units and shall be able to be used in conjunction with all room controller types. Collective and individual group commands are available with permit/prohibit individual remote controller function. At least five system controllers shall be able to reside on any one communication bus. Controller shall be interlocked to the Building management System.

2.6 MAINTENANCE ACCESS

A. Provide all gateways and connection cabling for performing maintenance functions on system.

B. Provide all software and registration codes as required to allow access into advanced maintenance functions.

2.7 ROOF MOUNTING CURB

A. Curb height as shown on drawings, minimum 14 gauge galvanized steel, one-piece construction, insulated, all welded, wood nailer.

2.8 EXPANSION COMPENSATION

A. Assembly consisting of two flexible connectors, two copper flexible connectors, two 90° elbows, and a 180° return pipe. Unit shall be in the form of a pipe loop.

B. Connectors shall have corrugated copper hose bodies with copper braided casings.

C. Connectors shall be rated for 150 psi working pressure at 70°F.

D. Sizes 2" and smaller shall have copper sweat ends.

E. Connectors shall be suitable for 1/2" permanent misalignment.

F. Install in every straight run of hard drawn seamless copper tube; 30 feet long or longer. Expansion compensation is not required for flexible line sets.

G. Manufacturer:

1. Metraflex Type MLS

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

B. Install in accordance with manufacturer's instructions. Install all piping, fittings, and insulation to meet manufacturer's requirements. Install units level and plumb. Evaporator fan components shall be installed using manufacturer's standard mounting devices securely fastened to building structure. Install and connect refrigerant tubing and fittings.

C. Installing contractor shall attend manufacturer sponsored training to obtain installation certification.

D. Installer shall supply isolation ball valves for zoned refrigerant isolation. Installer shall supply isolation ball valves with Schrader connection for isolating refrigerant charge and evacuation at each connected indoor unit and heat pump unit. Isolation ball valves, with Schrader connection, are required for instances of indoor unit isolation for troubleshooting, repair, or replacement without affecting the remainder of the system. Isolation ball valves with Schrader connection are also required at heat pump unit connection to isolate unit for troubleshooting, repair, or replacement and as required to provide partial capacity heating/cooling in the instance of a failure of one of the multiple heat pump unit compressors.

E. Insulate all refrigerant pipes between the heat pump and indoor units. This includes the liquid pipe, the suction pipe, the hot gas pipe, and the high/low pressure gas pipe. All fittings, valves, and specialty refrigerant components in the piping between the indoor and heat pump units shall also be insulated. The insulation shall have a continuous vapor barrier and shall pass through hangers and supports unbroken. All exterior insulated piping shall be painted with minimum of one (1) coat of UV resistant paint. Over size hangers and supports to allow the insulation to pass through unbroken. Following are the minimum insulation thicknesses unless noted otherwise in the manufacturer's literature or required by local AHJ:

1. ASHRAE 2016:

a. Refrigerant Suction (40°F & Below):

1) Up to 1": 1/2"
2) 1" and up: 1"

b. Refrigerant Suction (41°F to 60°F):

1) Up to 1-1/2": 1/2"
2) 1-1/2" and up: 1"

c. Refrigerant Low Pressure Gas (141°F-200°F):

1) Up to 1-1/2": 1-1/2"
2) 1-1/2" and up: 2"

d. Refrigerant High Pressure Gas (201°F-250°F):

1) Up to 4": 2-1/2"

e. Refrigerant Liquid:

1) Up to 1-1/2": 1"
2) 1-1/2" and up: 1-1/2"

F. Engage manufacturer or factory-authorized service representative to perform startup service. Manufacturer shall provide on-site startup and commissioning assistance through job completion. Complete installation and startup checks according to manufacturer's written instructions.

G. Fully charge system with refrigerant per manufacturer's requirements.

H. Field Quality Control:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections, and to assist in field testing.
2. Perform the following field tests and inspections, and prepare test reports:

a. Positive Pressure Leak Test: After installation, test for leaks by charging the system per manufacturer’s airtight positive test criteria for a minimum of 24 hours. Repair leaks and retest until no leaks exist.
b. Negative Pressure Leak Test: After positive pressure leak test, evacuate the system with a vacuum pump per manufacturer’s vacuum drying test criteria. The system shall maintain vacuum without pump operation or gauge movement for a minimum of 1 hour. If the gauge rises, the system may contain moisture or have leaks. Repair leaks and retest until no leaks exist. Manufacturer shall be present to witness the negative pressure test.
c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
e. Provide field test reports to manufacturer to include with manufacturer’s startup report.

I. Coordinate installation of units with architectural and electrical work. Coordinate installation of ceiling recessed units with ceiling grid layout. Additional ceiling grid reinforcement or modification is the responsibility of the Mechanical Contractor and shall be coordinated with the General Contractor.

J. Verify locations of wall-mounted devices (such as thermostats, temperature and humidity sensors, and other exposed sensors) with drawings and room details before installation. Coordinate mounting heights to be consistent with other wall-mounted devices. Height above finished floor shall not exceed 48".

K. Contractor is responsible for routing all condensate drains from all indoor equipment to a nearby floor drain or standpipe. If ceiling heights or space finish does not accommodate gravity drainage, Contractor is responsible for providing a condensate pump and all electrical work required.

L. Contractor is responsible for installing VRF heat pump control system. Contractor shall coordinate with the Temperature Controls Contractor to determine extent of integration with building automation system (BAS). Equipment that is required to integrate the VRF heat pump system with the BAS is the responsibility of the VRF heat pump installing contractor. Final connections between VRF heat pump system and BAS shall be by the Temperature Controls Contractor.

3.2 JOINING OF PIPE

A. Brazed Joints:

1. Make up joints with brazing filler metal conforming to ANSI/AWS A5.8. Cut copper tubing ends perfectly square and remove all burrs inside and outside. Thoroughly clean sockets of fittings and ends of tubing to remove all oxide, dirt and grease just prior to brazing. Apply flux evenly, but sparingly, to all surfaces to be joined. Brazing filler metal with a flux coating may also be used. Heat joints uniformly to proper brazing temperature so braze filler metal flows to all mated surfaces. Wipe excess braze filler metal, leaving a uniform fillet around cup of fitting.
2. Flux shall conform to ANSI/AWS A5.31.
3. Remove composition discs and all seals during brazing if not suitable for a minimum of 840°F (or greater than the melting temperature of the brazing filler metal, whichever is greater).

END OF SECTION 23 81 45

SECTION 23 82 00 - TERMINAL HEAT TRANSFER UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Finned Tube Radiation.

B. Fan Coil Units.

C. Unit Ventilators - Horizontal Type

D. Unit Ventilators - Vertical Upright Type

1.2 QUALITY ASSURANCE

A. All filters shall be UL listed Class 1 or Class 2.

B. All electrical equipment shall have a UL label.

1.3 SUBMITTALS

A. Submit shop drawings per Section 23 05 00.

B. Submit catalog data including arrangements, cross sections of cabinets, grilles, bracing, typical elevations.

C. Submit schedules of equipment and enclosures indicating length, number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, and comparison of specified to actual heat output.

D. Indicate mechanical and electrical service locations and requirements. Show deviations from scheduled products.

E. Submit manufacturers' installation instructions.

F. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

1.4 DELIVERY, STORAGE AND HANDLING

A. Protect units from physical damage by storing in protected areas and leaving factory covers in place.

1.5 REGULATORY REQUIREMENTS

A. Conform to ASHRAE 90.1.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit manufacturer's operation and maintenance data. Include operating, installation, maintenance and repair data, and parts listings.

PART 2 - PRODUCTS

2.1 FINNED TUBE RADIATION - WALL HUNG

A. Cabinets shall be 14 gauge steel with baked enamel finish.

B. Final color selection shall be by the Architect.

C. Element hangers shall be quiet operating, cradle type.

D. Cabinet top shall be continuously supported on wall mounting strips. Lower front face of cabinet shall be secured to the enclosure brackets.

E. All cabinet and accessories shall be securely connected with no exposed fasteners.

F. Provide end caps, corner pieces, adjustable extensions, etc. as required for proper appearance and service.

G. Provide custom cabinet at corners where, in the Architect/Engineer's opinion, standard fittings will not fit correctly or have acceptable appearance. Custom cabinet shall be 14 gauge sheet metal with finish and shape to match manufacturer's cabinet. Submit drawings of each custom cabinet for approval.

H. Provide removable cabinet sections at all control valves. It shall not be necessary to remove several sections to maintain control valves.

I. Support 1/2" tubes on 36" centers and larger tubes on 48" centers.

J. Elements shall be copper tube with aluminum fins.

K. Cabinet size, element length, and element size shall meet the scheduled capacities, but not be less than the sizes scheduled.

L. Products:

1. Vulcan 'Linovector.'
2. Sterling 'Versa-Line.'
3. Zehnder-Rittling 'Regency.'
4. Shaw-Perkins 'Crown-Line.'

2.2 FAN COIL UNITS

A. Units shall include cabinet, fan, motor, coils, filter and discharge grille.

B. Exposed cabinets shall be minimum 18 gauge steel with baked enamel finish, color selected by the Architect and no plastic exposed parts.

C. Fans: Centrifugal forward-curved, double-width with galvanized steel scrolls.

D. All motors shall be three-speed permanent split capacitor with integral thermal overload protection.

E. Coils shall have copper headers and tubes and aluminum fins.

F. Install a drain pan under each cooling coil meeting requirements as outlined in ASHRAE 62.1. The drain pans shall extend the entire width of each coil, including piping and header if in the air stream. The length shall be as necessary to limit water droplet carryover beyond the drain pan to 0.0044oz per ft2 of face area per hour under peak sensible and peak dew point design conditions, considering both latent load and coil face velocity. Pitch drain pans in two directions towards the outlet, with a slope of at least 1/8" per foot.

G. Provide manufacturer provided condensate pumps for all horizontal fan coil units both ducted and non ducted applications. Wall mounted fan coil units shall include a condensate pump provided by manufacturer where noted on the drawings.

H. Provide auxiliary drain pan to collect condensation in the valve compartment.

I. Provide condensate level switch to prevent unit from operating if the drain becomes blocked.

J. Provide condensate piping and tie into drainage system.

K. Filters: 1" woven glass fiber disposable type.

L. Provide a factory-installed manual switch disconnect with load side fuse to protect any fan coil units with a maximum overcurrent protection rating of 20 amps or less.

M. Provide oversized left and right end piping compartments.

N. Provide with tamperproof cabinet front.

O. Provide with a motor cord quick disconnect.

P. Units shall have separate heating and cooling coils.

Q. Manufacturers:

1. Daikin.
2. Air-Therm.
3. Trane
4. IEC.
5. Enviro-Tech/JCI.
6. Nailor.
7. Williams.
8. First Co.
9. Zehnder-Rittling.

2.3 UNIT VENTILATORS (TRADITIONAL HORIZONTAL TYPE)

A. Unit shall be in a blow through configuration and shall utilize DX cooling and heating water/steam heating coils per the control specifications.

B. Unit shall include cabinet, fan, motor, coil, filter, dampers, inlet grille, discharge grille, and outside air louver.

C. Cabinets shall have 16 gauge front, top, bottom and sides, with exposed edges rounded.

D. Baked enamel finish. Color selected by Architect.

E. Removable front panels secured with camlock fasteners.

F. Discharge Grilles: Heavy steel bars welded in place.

G. Inlet grilles shall be removable for access to filters.

H. Provide 6" false plenum back for all replacement unit ventilators.

I. Outside air louver shall be extruded aluminum with bird screen on the back side.

J. Provide wall sleeve for louver installation.

K. Cabinets shall have space at both ends for coil piping.

L. Unit shall have outside air and return air dampers. All dampers shall be gasketed for tight shutoff.

M. Provide with face and by-pass damper configuration for coil freeze protection.

N. Fans: Forward curved, double width, factory balanced, direct drive.

O. Motors shall be two-speed permanent split capacitor type.

P. Coils: Plate fin type with copper tubes and aluminum fins.

Q. Provide separate hot water/steam and DX cooling coils as scheduled on the drawings.

R. The heating coil is to be in the reheat position.

S. Install a drain pan under each cooling coil meeting requirements as outlined in ASHRAE 62.1. The drain pans shall extend the entire width of each coil, including piping and header if in the air stream. The length shall be as necessary to limit water droplet carryover beyond the drain pan to 0.0044oz per ft2 of face area per hour under peak sensible and peak dew point design conditions, considering both latent load and coil face velocity. Pitch drain pans in two directions towards the outlet, with a slope of at least 1/8" per foot.

T. Provide manufacturer provided condensate pumps for all unit ventilators.

U. Provide 1" thick disposable filter upstream of the coil.

V. Unit shall have valve to control discharge temperature. Refer to control section for further detail.

W. Provide unit mounted disconnect/speed switch.

X. Manufacturers:

1. Daikin
2. Trane.
3. Engineered Air.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. General Installation Requirements:

1. Install all products per manufacturers' instructions.
2. Coordinate recess sizes for recessed equipment.
3. Protect units with protective covers during construction.
4. Comb all coils to repair bent fins.

B. Fin Tube:

1. Locate finned tube radiation as shown and run cover wall-to-wall, unless otherwise shown. Center elements under windows.

C. Unit Heater:

1. Hang unit heaters from building structure, not from piping. Mount as high as possible within manufacturer's recommended mounting height requirements. If unit heaters cannot be installed within manufacturer's recommended range, notify Architect/Engineer prior to mounting.

D. Unit Ventilator:

1. Coordinate exact locations of unit ventilators. Level units and support from floor or structure.

### 3.2 CLEANING

A. After construction is complete, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

B. Touch-up marred or scratched surfaces of factory-finished cabinets, with materials furnished by manufacturer.

C. Install new filters.

END OF SECTION 23 82 00