DIVISION 23 – HVAC INDEX

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SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

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

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 23.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Sustainable Design Requirements – Division 01.
2. Cast-In place concrete – Division 03- Concrete
3. Steel Roof Decking - Division 05- Metals
4. Metal Fabrications - Division 05- Metals
5. Flashing Wall and Roof Penetrations - Division 07- Thermal and Moisture Protection
6. Sealants and Caulking - Division 07- Thermal and Moisture Protection
7. Painting - Division 09 - Finishes
8. Division 21 – Fire Protection
9. Division 22 – Plumbing
10. Division 23 – Heating, Ventilating and Air Conditioning – All Sections
11. Division 26 – Electrical
12. Other Divisions of this Specification where applicable

1.3 REFERENCE STANDARDS

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

B. Air-Conditioning, Heating and Refrigeration Institute (AHRI).

C. American National Standard Institute (ANSI):

D. Air Moving and Conditioning Association (AMCA):

E. American Society of Mechanical Engineers (ASME):

F. American Society for Testing and Materials (ASTM):

G. National Fire Protection Association (NFPA):

H. American Association of Balancing Contractors (AABC).

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

J. American Welding Society (AWS)

K. Environmental Protection Agency (EPA).

L. National Environmental Balancing Bureau (NEBB).

M. National Electrical Code (NEC)

N. Occupational Safety and Health Administration (OSHA).

O. Underwriters Laboratories (UL).

P. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

1.4 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and as specified in Division 01 Section titled "SUBMITTAL PROCEDURES."

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

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

1. Scale drawings indicating insert and sleeve locations.

2. Scale drawings showing all piping and duct runs with sizes, elevations, equipment service clearance and appropriate indication of coordination with other trades. This submission to us shall consist of an electronic file submittal and 2 paper prints.

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

4. Coordination drawings for access panel and door locations.

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

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

7. Welder Certificates signed by Contractor certifying that welders comply with requirements specified under "Quality Assurance" in this section.

D. Documents will not be accepted for review unless:

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

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

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

4. List of all deviations and exceptions from the specified requirements for the product is provided on the first sheet of the submittal.

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

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

E. Shop Drawing Review

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

2. Upon receipt of the approved manufacturers and material suppliers list, the Contractor shall immediately obtain complete Shop Drawings, Product Data and Samples and equipment and material Specification Compliance Review documents from the manufacturers, suppliers, vendors and all Division 23 Contractors, for all materials and equipment as specified herein in various sections of the specifications and shall submit data and details of such materials and equipment for review by the Architect and Engineer. Prior to submission of the Shop Drawings, Product Data and Samples to the Architect and Engineer, the Contractor shall thoroughly review the Shop Drawings, Product Data and Samples and certify they are in compliance with the Contract Documents. The Contractor shall provide a compliance review ("Compliance Review") of the applicable Drawings, Specifications and Addenda for all equipment and materials. The Compliance Review will be a paragraph by paragraph review of the Specifications with the following information marked for each Specification section paragraph or in the margin of the original Specification and any subsequent Addenda.

   a. "C": Comply with no exceptions.

   b. "D": Comply with minor deviations. For each and every deviation, provide a numbered footnote with reasons for the proposed deviation and how the intent of the Specification can be satisfied.

   c. "E": Exception. Equipment, product or material does not comply. For each and every exception, provide a numbered footnote with reasons for each exception and suggest possible alternatives for the owner's consideration.

   d. "N/A": The specification paragraph does not apply to the proposed equipment, material or product.

   e. Unless a deviation or exception is specifically noted in the Compliance Review, it is assumed that the Contractor is in complete compliance with the Contract Documents. Deviations or exceptions taken in cover letters, subsidiary documents, by omission or by contradiction does not relieve the Contractor from being in complete compliance unless the exception or deviation has been specifically noted (explicitly, not by implication) in the Compliance Review.

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

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

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

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

F. Explanation of Shop Drawing Stamp

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

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

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

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

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

6. Verified for Electrical Services: Indicates that the electrical requirements has been confirmed with the electrical contract documents.

7. Architects Review Required: Indicates that the submission will required the Architects review.

8. Structural Review Required: Indicates that the submission will require the Structural Engineer’s review.

9. Acoustical Consultant Review Required: Indicates that the submission will require the acoustical consultant’s review.

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

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

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

1.5 QUALITY ASSURANCE

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

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

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

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

C. Products Criteria:

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

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

3. All products and equipment shall be tested and/or listed and labeled by approved agency, such as Underwriters Laboratories (UL), according to prescribed standard or by approved agency according to New York City Office of Technical Certification and Research (OTCR) approved criteria. It is the responsibility of this trade to demonstrate or obtain and pay for all costs and fees of such approval and, when applicable, to prepare and submit an alternative product application to OTCR for review and approval.

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

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

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

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

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

9. Note that the approval of shop drawings, or other information submitted in accordance with the requirements hereinbefore specified, does not assure that the Engineer, Architect, or any other Owner's Representative, attests to the dimensional accuracy or dimensional suitability of the material or equipment involved or the ability of the material or equipment involved or the mechanical performance of equipment. Approval of Shop Drawings does not invalidate the plans and specifications if in conflict, unless a letter requesting such change is submitted and approved on the Engineer's letterhead.

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

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

B. Unit shall be stored and handled in accordance with manufacturer's instructions.

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

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

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

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

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

H. Deliver, store and handle all materials to keep clean and protected from damage.

I. Store products in shipping containers and maintain in place until installation.

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

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

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

M. Protect equipment and other materials from damage after installed from construction debris and other damage.

1.7 PRECONSTRUCTION CONFERENCE PRIOR TO START OF WORK

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

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

1.8 SEQUENCING AND SCHEDULING

A. Coordinate mechanical equipment installation with other building components.

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

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

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

E. Coordinate connection of electrical services.

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

G. Coordinate requirements for access panels and doors where mechanical items requiring access are concealed behind finished surfaces. See paragraph titled “Separation of Work Between Trades” to determine whether access panels and doors the responsibility of the Contractor for Division 08 or the Contractor responsible for Division 23.

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

1.9 SUSTAINABLE DESIGN REQUIREMENTS

A. Implement practices and procedures to meet the project’s environment goals which include achieving LEED (Leadership in Energy and Environmental Design) green building certification. Ensure that the requirements related to these goals, as defined in Division 01 and this section are implemented to the fullest extent. It is the Contractor’s responsibility to refer to the applicable LEED version being followed for this project and comply with the specific requirements. The Contractor shall inform the Architect and LEED Consultant should proposed substitutions or changes affect the stated LEED requirements. Substitutions, or other changes to the work proposed by the contractor or their Subcontractors, shall not be allowed without express written consent of the Architect and LEED Consultant.

1.10 COORDINATION

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

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

C. Coordinate requirements for access panels and doors for mechanical items requiring access that are concealed behind finished surfaces.

D. Provide all designating signs for shutoff valves, control valves, alarms, and the like, as required by the agencies having jurisdiction.

1.11 COORDINATION DRAWINGS

A. Prepare coordination drawings in accordance with Division 01 Section titled "PROJECT COORDINATION," and in accordance with Section HVAC trade coordination drawings to a scale of 3/8"=1'-0" or larger; detailing major elements, equipment components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. The coordination drawings shall be produced using AutoCad 2011 or later software. The design drawings will be made available on disks in AutoCad format for use as a basis for the "Coordination" drawings. These documents remain the property of Cosentini Associates and shall be used for no other purpose without expressed, written consent. The contractor shall assume all liabilities resulting from unauthorized use or modifications to the drawings.

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

   a. Planned piping layout, including valve and specialty locations and valve stem movement.
   b. Planned duct system layout, including elbow radii and duct accessories.
   c. Clearances for supports.
   d. Clearances for installing and maintaining insulation.
   e. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
   f. Equipment connections and support details.
   g.
   h. Sizes and location of required concrete pads and bases.
   i. Clearances as required by Electric Code.

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

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

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

B. HVAC COORDINATION DRAWINGS

1. This Contractor shall prepare a complete set of construction Coordination Drawings showing all of the HVAC work (equipment, piping, ductwork, conduit, etc.) to be installed as part of the work of this section of the specifications.

2. The Coordination Drawings shall be prepared on electronic media (CADD) at not less than 3/8": 1'-0" scale.

3. Requirements for vibration isolation shall be shown on the coordination drawings by each trade.

4. The HVAC coordination drawings, shall serve as the base drawing to which all other contractors will overlay and add their work.

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

6. The sequence of coordination drawings shall be HVAC-PLBG-FP-ELEC-CM/GC.

7. The HVAC Contractor shall be designated as the lead contractor in the development of the composite layering process and shall be responsible for electronically restacking the various trade layers into the final composite (CADD) Drawings. Each trade shall draw their Work on separate layers represented by individual colors.

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

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

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

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

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

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

1.12 RECORD DOCUMENTS

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

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

2. The drawings shall show:-

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

b. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Refer to Division 23; Section titled “Identification for HVAC Piping, Ductwork and Equipment”. Indicate horizontal locations of underground piping.
c. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
d. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
e. Updating of all equipment schedule sheets.

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

C. Prior to developing any “as-built” drawings, the Contractor shall coordinate with the Owner, Architect, Engineer and other Contractors the drawing layers, colors, etc. of the CAD drawings.

D. The drawings shall be produced using AutoCAD software. The design drawing files will be made available should it be determined that such files would serve as suitable backgrounds for the "as-built" drawings. These documents remain the property of Cosentini Associates and shall be used for no other purpose without expressed, written consent. The contractor shall assume all liabilities resulting from unauthorized use or modifications to the drawings.

E. CAD files shall each correspond to a single drawing sheet and have all of the x-refs bound to the file. CAD fonts that are not in the standard AutoCAD group shall be embedded into the DWG file.

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

1. BIM or CADD electronic drawing files on CD-R or DVD-R in proper format.

2. One (1) set of reproducible drawings.

3. Two (2) sets of blueprints.

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

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

I. As-built drawings for filing with the Building Department (where required) shall be prepared at the same scale, in the same plan format and use the same symbols and nomenclature as the plans filed by Engineer of Record with the Building Department for “Building Permit.”

1.13 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 01. In addition to the requirements specified in Division 01, include the following information for equipment items:

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

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

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

4. Servicing instructions and lubrication charts and schedules.

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

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

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

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

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

1.14 CODES, PERMITS AND INSPECTIONS

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

1. NFPA National Fire Codes

2. New York State Department of Health

3. New York State Building Code

4. All work shall meet or exceed USGBC LEED requirements when applicable.

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

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

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

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

F. This contractor shall prepare all plans, amendments and pay all filing fees that will be required for the emergency or standby or an optional generator installation, including oil piping, engine exhaust, fuel tanks, and any or all parts of the system under the jurisdiction of the controlling agencies. Register the generator with the local agencies.

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

1.15 SEPARATION OF WORK BETWEEN TRADES

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

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

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

Oth = Divisions other than Electrical (Division 26) or Mechanical (Divisions 21, 22 & 23)

Plb = Plumbing

Htg = Heating, Ventilating & Air Conditioning

Elec = Electrical

F = Furnished

I = Installed

P = Provided (furnished and installed)

Item	Oth	Plb	Htg	Elec	Notes
Motors for mechanical equipment.			P		
Motor Starters for Mechanical Equipment			F	I	Specifications and Drawings delineate exception
Controls Device for Mechanical Equipment			P		

Item	Oth	Plb	Htg	Elec	Notes
Power wiring for mechanical equipment motors.				P	Specifications and drawings delineate exceptions.
Control wiring for motors.			P		Specifications and drawings delineate exceptions.
Wiring for automatic dampers.			P		Specifications and drawings delineate exceptions.
Temporary heat.	P				
Temporary water.	P				
Sealing of pressurized stairway, shafts and doors.	P				
Undercutting of doors and door louvers.	P				Supplying location where required included in HVAC.
Temporary light & power.	P				
Hoisting			P		
Rigging			P		
Cutting, chasing & patching	P				Cost where due to late installation or improper coordination of work is the responsibility of the delinquent trade.
Framed slots and openings in walls decks and slabs.	P				Coordination drawings are required from HVAC trade.
Sleeves through non-membraned slabs, decks and walls.			P		
Drilling & cutting of all holes in steel decks and precast slabs required for sleeves & supports.			P		
Sleeves through membraned slabs, decks and walls.			P		
Waterproof sealing of sleeves through membraned slabs, decks and walls.			P		
Fastenings			P		
Supports			P		
Base flashing to all roof penetrations	P				
Roof curb cap flashing.			P		
Roof curb base flashing	P				

Item	Oth	Plb	Htg	Elec	Notes
Concrete foundations, pads & bases inside buildings.	P				Furnishing of anchors, vibration mounts and seismic restraints included in the HVAC trade.
Concrete foundations, pads & bases outside buildings.	P				Furnishing of anchors, vibration mounts and seismic restraints included in the HVAC trade providing the associated equipment.
Field touch-up painting of damaged shop coats.			P		
Rustproofing field cut and assembled iron supporting frames and racks.			P		
Finish painting of exposed work.	P				Insulation coatings are by HVAC trade.
Ornamental grills.	P				Duct connections included in HVAC trade.
Exterior wall louvers.	P				Duct connections & safing of all unused portions of louvers (2" thick insulated panel) is by HVAC Trade.
Finished Wall and Ceiling Access Doors and Supporting Frames	I	F			HVAC Contractor shall locate the doors on approved shop drawings and shall be held responsible for the accessibility of all concealed valves, controls, equipment, etc.
Thermal insulation for mechanical room ceilings.	P				
Heating Convector Enclosure	P				HVAC Contractor shall provide list of enclosure locations and physical dimensions
Fin-tube Radiation Enclosure	P				HVAC Contractor shall provide list of enclosure locations and physical dimensions
Catwalks to mechanical equipment.	P				Supplying list of locations where required included in HVAC.
Ladders to mechanical equipment other than cooling towers	P				Supplying list of locations where required included in HVAC.

Item	Oth	Plb	Htg	Elec	Notes
Ladders to roof mounted AC units and HVAC equipment.			P		Coordinate with Architect and Structural Engineer.
Steel dunnage for roof mounted AC units and HVAC equipment other than cooling towers.			P		Coordinate with Architect and Structural Engineer.
Rubbish removal			P		Where one trade furnishes and another installs, the installing trade removes the shipping and packing materials which accumulate.
Special tools for equipment maintenance.			F		Special tools are defined as tools proprietary to a particular type or piece of equipment.
Electric duct heaters (heaters installed in air ducts).			P		Line connections included in electric. Drawings delineate exceptions.
Electric heaters with integral fans (cabinet heaters, unit heaters and the like).			P		Line connections included in electric. Drawings delineate exceptions.
Electric radiators (baseboard, sill line, and convector type heaters).				P	
Electric heater cables for radiant space heating.				P	
Electric heater cables for pipe tracing.				P	Line and control connections and control device mounting included in electric.
Access platforms for roof mounted AC units			P		Manufacturer to design access platforms with all associated structural elements to be furnished and installed by the HVAC contractor.

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

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

1. The coordination of their delivery.

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

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

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

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

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

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

F. Items which are to be installed, but not purchased as part of the work of the Division 23, shall be carefully examined by this Contractor upon delivery to the project. Claims that any of these items have been received in such condition that their installation will require procedures beyond the reasonable scope of work of Division 23 will be considered only if presented in writing within one week of the date of delivery to the project of the items in question. The work of this Contractor shall include all procedures, regardless of how extensive, necessary to put into satisfactory operation, all items for which no claims have been submitted as outlined above.

1.16 DEFINITIONS

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

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

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

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

4. "By Other Trades" or "Others" or "Oth"-------By persons or parties responsible for work at the project other than the party or parties who have been duly awarded the contract for the work of Division 23. In the event that this document is used to acquire work as part of a general construction contract the words "by other trades" shall mean by persons or parties who are not anticipated to be the sub-contractor for Division 23 working together with the general contractor. In this context the words "by other trades" shall <u>not</u> be interpreted to mean not included in the overall contract.

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

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

1.17 INTERPRETATION OF THE DRAWINGS AND SPECIFICATIONS

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

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

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

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

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

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

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

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

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

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

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

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

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

1.18 EXAMINATION OF SITE AND CONTRACT DOCUMENTS

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

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

1.19 WORKMANSHIP

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

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

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

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

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

PART 2 – PRODUCTS

(Not Applicable)

PART 3 - EXECUTION

3.1 OPERATING INSTRUCTIONS

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

3.2 GUARANTEES AND CERTIFICATIONS

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

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

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

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

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

3.3 ROUGH-IN

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

B. Refer to equipment specifications in Division 02 through Division 33 for rough-in requirements.

3.4 MECHANICAL INSTALLATIONS

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

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

2. Verify all dimensions by field measurements.

3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.

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

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

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

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

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

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

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

11. Install access panel or doors for maintenance or inspection where units are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Sections titled “Access Doors and Frames” and Security Access Doors and Frames and a subsequent paragraph of this Section of Division 23.

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

3.5 PROTECTION AND CLEANING

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

B. The inlet and discharge openings of all fan coil, and other terminal units shall be kept covered until all local plastering, parging, etc. is completed, and the units are ready to run. The inlet and discharge openings of fans, air handling, Roof Mounted Air Conditioning, pumps, etc. shall be kept covered until connected to system.

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

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

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

3.6 FLUSHING AND CLEANING OF PIPING

A. All piping systems shall be thoroughly flushed out with the approved cleaning chemicals to remove pipe dope, slushing compounds, cutting oils, and other loose extraneous materials. This also includes any piping systems which are not listed as requiring water treatment.

B. Develop plan for flushing and cleaning piping. Submit plan for approval prior to completion of piping. Provide all temporary and permanent piping, equipment, materials necessary to complete flushing and cleaning.

C. Prior to flushing, temporarily remove, isolate or bypass dirt sensitive equipment and devices.

D. Provide temporary pumps and piping to flush and chemically clean piping at a minimum velocity of 6 fps without using the system pumps.

E. Prior to flushing, install fine mesh construction strainers at inlet to all equipment with connections 2 1/2" and larger. Install fine mesh construction element in permanent strainers. During flushing and cleaning, remove and clean strainers periodically. At completion of final flush, clean permanent strainers, remove construction strainers.

F. Flush all piping with cold water for a minimum of 6 feet per second for one hour, until water runs clear. Water supply shall be equivalent to piping to be flushed. Drain all low points.

G. Circulate flush water and clean strainers prior to installing cleaning chemicals. Provide cleaning chemicals, under the direction of the chemical supplier. Following flushing, install cleaning chemicals and circulate through the entire system for a minimum of one hour, or as directed by chemical supplier. Take water sample for owner's use. Drain system, including all low points.

H. Flush, drain and fill system, circulate for one hour, sample for owner's use. Drain, flush, fill, circulate and sample until system is free of cleaning chemicals, as indicated by analysis of samples.

I. The cleaning chemicals shall be added by the mechanical trade. The chemical supplier shall verify that the chemicals are compatible with all the materials in the systems. The chemical supplier shall instruct as to the proper feed rates, shall check that the cleaning solution is actually in each system, shall instruct the contractor as to when to flush the system and shall check each system following flushing to ensure all cleaning chemicals have been removed from each system.

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

3.7 FIRE AND SMOKE DETECTION

A. Fire and smoke detection system will be provided and installed as part of the work of Division 26. The Contractor responsible for the work of Division 23 shall provide suitable openings (as recommended by the Smoke Detection System Manufacturer) in sheet metal for sensing elements.

B. The Contractor responsible for the work of Division 23 shall provide access doors to make all such detection heads accessible.

C. The Contractor responsible for the work of Division 23 shall provide bracing for smoke detection sampling tubes which exceed 48" in length.

3.8 DRIVE GUARDS

A. For all machinery and equipment (whether factory fabricated or field installed) provide OSHA approved guards for belts, chains, couplings, pulleys, sheaves, shafts, gears and other moving parts regardless of height above the floor.

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

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

3.9 TOOLS AND LUBRICANTS

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

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

3.10 PAINTING AND FINISHING

A. Refer to Division 09 titled "Finishes" for painting requirements.

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

C. Provide prime coat painting for the following if not provided with factory applied corrosion protection.

1. Miscellaneous steel and iron provided by Contractor responsible for the work of Division 23.

2. Hangers and supports iron provided by Contractor responsible for the work of Division 23.

3. Miscellaneous steel and iron provided by Contractor responsible for the work of Division 23 installed outdoors shall be provided with finished coats of exterior paint in accordance with requirements of Division 09 titled “Finishes” in addition to prime coat.

3.11 ACCESS DOORS IN FINISHED CONSTRUCTION

A. Access doors as required for operation and maintenance of concealed equipment, valves, controls, etc. will be provided as part of the work of Division 08.

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

C. Coordinate and prepare a location, size, and function schedule of access doors required and deliver to a representative of the Contractor for Division 08.

D. Furnish and install distinctively colored buttons in finished ceiling.

E. Access doors shall be of ample size to perform proper maintenance on concealed equipment, valves, controls, etc. but shall not be less than a minimum of 18" x 18".

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

A. This Contractor shall furnish access doors as required for operation and maintenance of concealed equipment, valves, controls, etc., and coordinate their delivery with the Contractor for Division 08. Installation of doors will be by the Contractor for Division 08 , but this Contractor shall locate the doors on approved shop drawings and shall be held responsible for the accessibility of all concealed valves, controls, equipment, etc. The delivery point for the access doors shall be where designated by the Construction ManagerGeneral ContractorOwner’s Representative, who shall coordinate the time of delivery with the Contractors involved

B. Coordinate and prepare a location, size, and function schedule of access required and deliver to a representative of the Contractor for Division 08.

C. Furnish and install distinctively colored buttons in finished ceiling.

D. Access doors shall be of ample size to perform proper maintenance on concealed equipment, valves, controls, etc. but shall not be less than a minimum of 18" x 18".

E. Access doors shall be as manufactured by Karp Associates, Inland Steel Products "Milcor" or other approved in accordance with the following schedule:

LOCATION	TYPE	CATALOG NUMBER
Wall and Ceiling	Recessed Door Panel for Plaster Recessed Door Panel for Drywall	Karp DSC-210-PL Milcor Style AP Karp RDWPD Milcor Style DWR
Acoustic Tile Ceiling	Recessed Door Panel for Tile	Karp DSC-210-AT Milcor Style AT
Wall and Ceiling	Non-Recessed Door Panel for Plaster	Karp DSC-214 PL Milcor Style K
Wall and Ceiling	Non-Recessed Door Panel for Drywall	Karp KDW Milcor Style DW
Ceramic Tile Walls	Non-Recessed Door Panel	Karp DSC-214-M Milcor Style M
Masonry Wall	Non-Recessed Door Panel	Karp DSC-214-M Milcor Style M

F. Doors and frames to be given a factory prime coat of corrosion resistant paint.

G. Frames shall be steel minimum gauge per manufacturer's standard gauge for model listed, welded mitered corners ground smooth with anchors.

H. Doors shall be steel minimum gauge per manufacturer's standard gauge for model listed, heavy hinges flush with frame, invisible when closed.

A. This Contractor shall furnish access doors as required for operation and maintenance of concealed equipment, valves, controls, etc., and coordinate their delivery with the Contractor for Division 08. Installation of doors will be by the Contractor for Division 08, but this Contractor shall locate the doors on approved shop drawings and shall be held responsible for the accessibility of all concealed valves, controls, equipment, etc. The delivery point for the access doors shall be where designated by the Construction ManagerGeneral ContractorOwner's Representative, who shall coordinate the time of delivery with the Contractors involved.

B. Coordinate and prepare a location, size, and function schedule of access required and deliver to a representative of the Contractor for Division 08.

C. Furnish and install distinctively colored buttons in finished ceiling.

D. Access doors shall be of ample size to perform proper maintenance on concealed equipment, valves, controls, etc. but shall not be less than a minimum of 18" x 18".

E. The doors shall be as follows:

1. Non-rated access doors as required for non-rated wall, partitions and ceiling construction.

2. Doors shall be complete with mortise cylinder locks, steel piano hinges with stainless steel pin, anchors, and a prime coat of corrosion resistant, factory applied, paint. All frames for access doors shall be of design suitable for the construction into which it will be installed.

3. Construction - Doors shall be factory made, flush metal construction of not less than No. 16 gauge metal thickness for frames, and door panels not less than 20 gauge. Frames shall be of welded construction with mitered corners. All welds shall be ground smooth. Hinges shall be flush with frame, invisible when door is closed.

4. Access doors shall be recessed or non-recessed type as selected by Architect.

5. See Division 08 for additional access door requirements.

3.12 PRE-OCCUPANCY SPACE FLUSH OUT

A. At completion of construction, prior to turn over of the building, the contractor shall conduct a pre-occupancy flush out of the system as follows:

1. All supply air systems shall be run at 100% fan capacity for a period of two weeks. For systems with return air fans, fan shall run at 100% fan capacity.

2. During the flush out, all outside air dampers shall be locked into the 100% outside air position. Return air dampers shall be fully closed and all spill air dampers shall be 100% open. Exhaust fans shall be operated at 100% exhaust.

3. Cooling and/or heating coil valves shall be controlled by the building management system to provide properly tempered and dehumidified air.

a. Supply air temperature shall be set to provide a maximum space temperature of 78°F, minimum space temperature of 66°F and a maximum space humidity of 60% RH.

4. All exhaust fans that are required to run to maintain proper building pressurization shall be operated at 100% fan capacity for the flush out period.

3.13 REFRIGERANT HANDLING

A. Refrigerant Installation and Disposal: Perform all work related to refrigerant contained in chillers, cooling coils, air conditioners, and similar equipment, including related piping, in strict accordance with the following requirements:

1. ASHRAE Standard 15 and Related Revisions: Safety Code for Mechanical Refrigeration.

2. ASHRAE Standard 34 and Related Revisions: Number Designation and Safety Classification of Refrigerants.

3. United States Environmental Protection Agency (US EPA) requirements of Section 808 (Prohibition of Venting and Regulation of CFC) and applicable State and local regulations of authorities having jurisdiction.

B. Recovered refrigerant is the property of the Contractor. Dispose of refrigerant legally, in accordance with applicable rules and regulations of authorities having jurisdiction.

END OF SECTION 23 05 00
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SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

B. Related Sections

1. Division 23 Section 230547 Vibration Controls for Mechanical and Electrical Systems (Non-Seismic)
2. Division 23 Section 230514 Enclosed Controllers
3. Applicable Sections of Division 26 PRODUCTS

1.3 DEFINITIONS

A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.

B. Field-Installed Motor: A motor installed at Project site and not factory installed as an integral component of motorized equipment.

1.4 SUBMITTALS

A. Product Data for Field-Installed Motors: For each type and size of motor, provide nameplate data and ratings; shipping, installed, and operating weights; mounting arrangements; size, type, and location of winding terminations; conduit entry and ground lug locations; and information on coatings or finishes.

B. Shop Drawings for Field-Installed Motors: Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:

1. Each installed unit's type and details.
2. Nameplate legends.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain field-installed motors of a single type through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70, as amended by state and local codes.

D. COORDINATION

1. Coordinate features of motors, installed units, and accessory devices. Provide motors that are:

2. Compatible with the following:

a. Magnetic controllers.
b. Multispeed controllers.
c. Reduced-voltage controllers.

3. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.
4. Matched to torque and horsepower requirements of the load.
5. Matched to ratings and characteristics of supply circuit and required control sequence.
6. Motor compatible with ambient and environmental conditions of motor installation

E. Coordinate motor support with requirements for driven load; access for maintenance and motor replacement; installation of accessories, belts, belt guards; and adjustment of sliding rails for belt tensioning.

F. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

A. Motor requirements apply to factory-installed and field-installed motors except as follows:

1. Different ratings, performance, or characteristics for a motor are specified in another Section.
2. Manufacturer for a factory-installed motor requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

2.2 MOTOR CHARACTERISTICS

A. Motors ½ HP and Larger: Three phase.

B. Motors Smaller Than ½ HP: Single phase.

C. Frequency Rating: 60 Hz.

D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.

E. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.

F. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) above sea level.

G. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

H. Enclosure: Open dripproof.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design E, medium induction motor. Efficiency in accordance with NEMA standards for Premium Efficient motors and with applicable EPACT Efficiency Standards.

B. Stator: Copper windings, unless otherwise indicated.

1. Multispeed motors shall have separate winding for each speed.

C. Rotor: Squirrel cage, unless otherwise indicated.

D. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading.

E. Temperature Rise: Match insulation rating, unless otherwise indicated.

F. Insulation: Class F, unless otherwise indicated.

G. Code Letter Designation:
1. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

H. Enclosure: rolled steel for motors smaller than 7.5 hp.

1. Finish: Gray enamel.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: copper magnet with moisture-resistanceinsulation varnish, designed and tested to resist spikes, high frequency and short time rise pulses produced by pulse-width modulated inverts.
2. Provide a maintenance free, circumferential, conductive micro fiber shaft grounding ring (Aegis Bearing Protection Ring or similar) on the AC motor to discharge shaft currents to ground. For motors 100 horsepower or less, provide a shaft ground ring on either the drive end or non-drive end in accordance with the manufacturer's recommendations.
3. Designed with critical vibration frequencies outside operating range of controller output.
4. Temperature Rise: Matched to rating for Class B insulation.
5. Insulation: Class H.
6. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
7. Inverter rated: Comply with NEMA MG-1 Part 31.4.4.2 requirements for inverter rated motors.

C. Severe/Rugged-Duty Motors: Comply with IEEE841, totally enclosed, with 1.25 minimum service factor, greased bearings, integral condensate drains, and capped relief vents. Windings insulated with nonhygroscopic material.

1. Finish: Chemical-resistant paint over corrosion-resistant primer.

2.5 SINGLE-PHASE MOTORS

A. Type: One of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split-phase start, capacitor run.
3. Capacitor start, capacitor run.
4. Shaded-Pole Motors: For motors 1/20 hp and smaller only.

B. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

C. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, prelubricated-sleeve type for other single-phase motors.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive field-installed motors for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in of conduit systems to verify actual locations of conduit connections before motor installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 MOTOR INSTALLATION

A. Anchor each motor assembly to base, adjustable rails, or other support, arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and align with load transfer link.

B. Install motors on concrete bases complying with Division 03.

C. Comply with mounting and anchoring requirements specified in Division 23.

3.3 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
2. Test interlocks and control features for proper operation.
3. Verify that current in each phase is within nameplate rating.

B. Testing: Perform the following field quality-control testing:

1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.15.1. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.4 ADJUSTING

A. Align motors, bases, shafts, pulleys and belts. Tension belts according to manufacturer's written instructions.

3.5 CLEANING

A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean motors, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 23 05 13

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SECTION 23 05 14 - ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes the following enclosed controllers rated 600 V and less:

1. Full-voltage manual.
2. Full-voltage magnetic.
3. Reduced-voltage magnetic.
4. Multispeed.

B. Related Section:
1. Division 26 Installation of Enclosed Controllers
2. Division 26 Selection of Overcurrent Devices for OCD's and disconnect switches for use with motor controllers.

1.3 DEFINITIONS

A. CPT: Control power transformer.

B. MCCB: Molded-case circuit breaker.

C. MCP: Motor circuit protector.

D. N.C.: Normally closed.

E. N.O.: Normally open.

F. OCPD: Overcurrent protective device.

G. SCR: Silicon-controlled rectifier.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.

B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.

1. Show tabulations of the following:

a. Each installed unit's type and details.
b. Factory-installed devices.
c. Nameplate legends.
d. Short-circuit current rating of integrated unit.
e. Listed and labeled for integrated short-circuit current (withstand) rating of OCPDs in combination controllers by an NRTL acceptable to authorities having jurisdiction.
f. Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.

2. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Field quality-control reports.

C. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

D. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for enclosed controllers and installed components.
2. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
3. Manufacturer's written instructions for setting field-adjustable overload relays.
4. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage solid-state controllers.

1.7 MATERIALS MAINTENANCE SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.

4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70 as amended by state and local codes.

C. Listing and Labeling: Provide products specified in this section that are Underwriters Laboratories listed and labeled.

1. The terms "listed" and "labeled" shall be as they are in the National Electrical Code, Article 100.

D. Single Source Responsibility: Obtain similar motor control devices from a single manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).

2. Altitude: Not exceeding 6600 feet (2010 m).

1.11 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

D. Coordinate features of enclosed controllers and accessories with pilot devices and control circuits to which they connect.

E. Coordinate features, accessories and functions with rating and characteristics of supply circuits, required control sequences and duty cycle of motor and load.

PART 2 - PRODUCTS

2.1 FULL-VOLTAGE CONTROLLERS

A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.

B. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
c. Rockwell Automation, Inc.; Allen-Bradley brand.
d. Siemens Energy & Automation, Inc.
e. Square D; a brand of Schneider Electric.

2. Configuration: Nonreversing, Reversing or Two speed.
3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 20 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
4. Flush or Surface mounting.
5. Red or Green pilot light.
6. Additional Nameplates: HIGH and LOW for two-speed controllers.

C. Integral Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
c. Rockwell Automation, Inc.; Allen-Bradley brand.
d. Siemens Energy & Automation, Inc.
e. Square D; a brand of Schneider Electric.

2. Configuration: Nonreversing.

3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 20 tripping characteristics; heaters and sensors in each phase, matched to nameplate full-load current of actual protected motor and having appropriate adjustment for duty cycle; external reset push button; bimetallic type.
4. Flush or Surface mounting.
5. Red or Green pilot light.
6. N.O. and N.C. auxiliary contact.
7. Low voltage protection.

D. Magnetic Controllers: Full voltage, across the line, electrically held.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
   c. Rockwell Automation, Inc.; Allen-Bradley brand.
   d. Siemens Energy & Automation, Inc.
   e. Square D; a brand of Schneider Electric.

2. Configuration: Nonreversing or Reversing.
3. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

   a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

4. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

   a. CPT Spare Capacity: 100%.

6. Bimetallic Overload Relays:

   a. Inverse-time-current characteristic.
   b. Class 20 tripping characteristic.
   c. Heaters and sensors in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
   d. Ambient compensated.

7. N.C. and N.O., isolated overload alarm contact.
8. External overload reset push button.

E. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
   c. Rockwell Automation, Inc.; Allen-Bradley brand.
   d. Siemens Energy & Automation, Inc.
   e. Square D; a brand of Schneider Electric.

2. Fusible Disconnecting Means:

   a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with rejection - type fuse clips for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by a Nationally Recognized Testing Laboratory.
   b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

3. Circuit-Breaker Disconnecting Means:

   a. NEMA AB 1, motor-circuit protector with field- adjustable, short-circuit trip coordinated with motor locked-rotor amperes
   b. Lockable Handle: accepts three padlocks and interlocks with cover in closed position.

4. Nonfusible Disconnecting Means:

   a. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
   b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
   c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

5. MCCB Disconnecting Means:

   a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
   b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   c. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
   d. N.C. and N.O. alarm contact that operates only when MCCB has tripped. Quantity as required.

6. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

2.2 REDUCED-VOLTAGE MAGNETIC CONTROLLERS

A. General Requirements for Reduced-Voltage Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A; closed-transition; adjustable time delay on transition.

B. Reduced-Voltage Magnetic Controllers: Reduced voltage, electrically held.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
   c. Rockwell Automation, Inc.; Allen-Bradley brand.
   d. Siemens Energy & Automation, Inc.
   e. Square D; a brand of Schneider Electric.

2. Configuration:

   a. Star-Delta Controller: NEMA ICS 2, closed transition with adjustable time delay, four contactors, with a three-phase starting resistor/reactor bank.
   b. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition, medium-duty service, with integral overtemperature protection; taps for starting at 50, percent of line voltage; two START and one RUN contactors.

3. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

   a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

4. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

   a. CPT Spare Capacity: 100 percent.

6. Bimetallic Overload Relays:

   a. Inverse-time-current characteristic.
   b. Class 20 tripping characteristic.
   c. Heaters and sensors in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
   d. Ambient compensated.

7. N.C. and N.O., isolated overload alarm contact.
8. External overload reset push button.

C. Combination Reduced-Voltage Magnetic Controller: Factory-assembled combination of reduced-voltage magnetic controller, OCPD, and disconnecting means.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
   c. Rockwell Automation, Inc.; Allen-Bradley brand.
   d. Siemens Energy & Automation, Inc.
   e. Square D; a brand of Schneider Electric.

2. Fusible Disconnecting Means:

   a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with rejection type fuse clip, for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by a Nationally Recognized Testing Laboratory.
   b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

3. Circuit-Breaker Disconnecting Means:

   a. NEMA AB 1, motor-circuit protector with field- adjustable, short-circuit trip coordinated with motor locked-rotor amperes
   b. Lockable Handle: accepts three padlocks and interlocks with cover in closed position.

4. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

5. Nonfusible Disconnecting Means:

   a. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
   b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
   c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

6. MCCB Disconnecting Means:

   a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
   b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   c. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
   d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
   e. N.C. and N.O. alarm contact that operates only when MCCB has tripped. Quantity as required.

2.3 RATINGS

A. Controllers bear UL short Circuit rating of 100,000 amps with appropriate line side fuses on a series rated basis and labeled accordingly

2.4 WIRING

A. All wiring within controllers shall be copper.

2.5 ENCLOSURES

A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: NEMA 250 Type 1.
2. Outdoor Locations: NEMA 250, Type 3R .
3. Other Wet or Damp Indoor Locations: NEMA 250 Type 4.

B. Covers are interlocked with disconnecting means.

2.6 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty type.

a. Push Buttons: Recessed types; momentary as indicated.
b. Pilot Lights: LED types; colors as indicated; push to test.
c. Selector Switches: Key-operated with key removable only “Remote” or “Auto” position as applicable.

B. Reversible N.C./N.O. auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Relays: Provide auxiliary and adjustable time-delay relays as follows:

1. Auxiliary control circuit relay for each magnetic controller NEMA Size 1 and larger, arranged to prevent holding coil currents into the external control circuit.
2. Phase-failure and undervoltage relay for each magnetic controller size 5 and larger. Adjustable undervoltage setting.
3. Undervoltage lockout relay for magnetic controllers where so indicated on drawings.

E. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

F. Breather and drain assemblies, to maintain interior pressure and release condensation in Type 4enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

G. Space heaters, with N.C. auxiliary contacts, to mitigate condensation in Type 3Renclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

H. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

I. Cover gaskets for Type 1 enclosures.

J. Terminals for connecting power factor correction capacitors to the load side of overload relays.

K. Spare control wiring terminal blocks, quantity as indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation of motor controllers will be performed as part of the work of Division 26 (Electrical).

B. Installation of motor control devices will be performed as part of the work of Division 23.

3.2 APPLICATIONS

A. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, drive, and load; and configuration of pilot device and control circuit affecting controller functions.

B. Select horsepower rating of controllers to suit motor controlled.

C. Use fractional-horsepower manual controllers for single-phase motors, unless otherwise indicated.

D. Hand-Off-Automatic (and Hand-Off-Remote) Selector Switches: Except as otherwise indicated, factory install in covers of manual and magnetic controllers of motors started and stopped by central control system and/or automatic controls or interlocks with other equipment. Make control connections so only the manual and automatic control devices that have no safety functions will be bypassed when the switch is in the hand position. Connect motor control circuit in both hand and automatic positions for safety type control devices such as low - and high - pressure cutouts , high temperature cutouts, and motor overload protectors. Switches are of the key-operated cylinder lock type, with key removable only in auto (remote) position. All locks are keyed alike.

E. Pushbutton Stations: Except as otherwise indicated, momentary-contact, start-stop units. Provide in covers of magnetic controllers for manually started motors where indicated, and connect start contact in parallel with sealing auxiliary contact for low voltage protection.

3.3 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed.

END OF SECTION 23 05 14

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SECTION 23 05 17 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal fittings.
4. Grout.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral 2" all-around waterstop continuously welded to sleeve.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends with a ¼ inch steel plate continuously welded to outside of pipe 2 inch all-around waterstop collar and zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. Galvanized-Steel-Sheet Sleeves: 16" Gauge minimum thickness; round tube closed with welded longitudinal joint.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Smith, Jay R. Mfg. Co.

2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Presealed Systems.

B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

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

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by removable molded-PE or -PP sleeves.

2. Cut sleeves to length for mounting flush (including Floor Finishes) with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas/rooms or other wet areas 2 inches (50 mm) above finished floor level.

b. For Roof construction, equal to depth of roof construction plus roof insulation.

3. Seal annular space between sleeve and piping or piping insulation use joint sealants appropriate for size, depth and location. Comply with requirements for sealants specified in Section 079200 "Joint Sealant"

4. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

C. Install sleeves for pipes passing through interior partitions.

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

2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.

3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.

2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."

3. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level.

4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

5. Using grout, seal the space around outside of stack-sleeve fittings.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

a. Piping Smaller than NPS 6 (DN 150): Galvanized-steel wall sleeves.

b. Seal annular opening between sleeve and pipe or pipe insulation with appropriate joint sealant that makes opening water-tight and air tight.

2. Concrete Slabs above Grade:

a. Piping Smaller than NPS 6 (DN 150) Galvanized-steel-pipe sleeves

b. Concrete floors, walls and roofs with membrane waterproofing and non-membrane floors, walls and roofs where flashing is required, stack-sleeve fittings shall be used.

3. Interior Partitions:

a. Piping Smaller than NPS 6 (DN 150) Galvanized-steel-sheet sleeves.

END OF SECTION 23 05 17

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SECTION 23 05 18 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated and rough brass finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

D. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.

E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed exposed-rivet hinge, and spring-clip fasteners.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening. Provide Close Fitting Escutcheons on both sides of piping (whether exposed or not) passing through required Floors, Partitions and Ceilings.

1. Escutcheons for New Piping:

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

b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

c. Insulated Piping: One-piece, Cast-Brass type or split, casting Brass type with concealed hinge.

d. Bare Piping at Wall in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

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

f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with Rough Brass finish.

g. Bare Piping in Equipment Rooms: One-piece, cast-brass split-casting brass type with rough-brass finish.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 23 05 18

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SECTION 23 05 23 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Ball valves.

2. Check valves.

3. Center-guided check valves. Gate valves.

B. Related Sections:

1. Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

a. Other related sections of Division 23.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve indicated.

B. Submit manufacturer's certification that the valve's pressure and temperature rating meets the systems working pressure and temperature requirements.

1.5 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source same manufacturer.

B. ASME Compliance:

1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.

2. ASME B31.1 for power piping valves.

3. ASME B31.9 for building services piping valves.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.

2. Protect threads, flange faces, grooves, and weld ends.

3. Set gatevalves closed to prevent rattling.

4. Set ball valves open to minimize exposure of functional surfaces.

5. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.

2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

B. Valve Sizes: Same as upstream piping unless otherwise indicated.

C. Valve Manual Actuator Types:

1. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.

D. Valves in Insulated Piping: Provide 2-inch stem extensions and the following features:

1. Gate Valves: With rising stem.

2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

E. Valve-End Connections:

1. Solder Joint: With sockets according to ASME B16.18.

F. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE BALL VALVES (SEE SECTION "D" BALL VALVE NOTES)

A. Two-Piece, - Standard Port, Bronze Ball Valves with Bronze Trim: (Type A).

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Conbraco Industries, Inc.; Apollo Valves. Series 70-100 (threaded); 70-200 (solder)

b. Crane Co.; Crane Valve Group; Crane Valves.

c. A division of Advanced Thermal Systems, Inc.

d. Milwaukee Valve Company. BA-100 (threaded); BA-150 (solder)

e. NIBCO INC. T-585-70 (threaded); S-585-70 (solder)

2. Standard: MSS SP-110 Description:

a. Valve size ½' thru 3"

B. 3-Piece Full Port Bronze Ball Valve Solder End (In-Line Serviceable Valve) with Bronze Trim for Copper Pipe Systems (Type AB)

1. Manufacturers: Subject to compliance with requirements, provide product by:

a. Conbraco Industries Inc.: Apollo Valve 82-200 Series, Valve size 3/8" to 4"

b. Milwaukee Valve Company: BA-350 Series, Valve size 3/8" to 3"

2. Description:

a. Standard ISO 9001-2008; MSS SP-110

b. For brazed installations or 95/5 solder

c. Valve size: 3/8" to 4"

d. CWP: 600 psi; SWP: 150 psi Series 82-200

e. CWP: 400 psi: SWP: 150 psi (82-240 Series 316 SS Ball & Stem)

C. Ball Valve Notes Typical for Hydronic ball valves Type A and Type AB.

1. Provide 2-1/4" stem extension for valve on insulated pipes.

2. Balancing stop for hydronic installations.

3. SWP Rating 150 psig @ 350F; CWP Rating 600 psig @150F.

4. 2 Piece 3" and smaller Ball valves in hydronic systems up to 200 F @ 200 psig and lower, and saturated steam systems up to a maximum 15 psig can be joined with 95/5 tin-antimony solder.

2.3 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc: (Type F).

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Stockham Division. Figure B-319Y

c. Milwaukee Valve Company. Figure 509

d. NIBCO INC. Figure T-413-BY

e. Powell Valves. Figure 578

2. Description:

Standard: MSS SP-80,

SWP Rating: 125 psig @ 406˚F CWP Rating 200 psig @ 150˚F

Check Valve Size: ½" thru 3"

2.4 SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats: (Type H).

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Stockham Division. Figure G-931, Bronze Trim (3" thru 24")

c. Milwaukee Valve Company. F2974 A Bronze Trim

d. NIBCO INC. Figure F-918 B, Bronze Trim

e. Powell Valves. Figure 559 w. Bronze Trim

2. Description:

a. Standard: MSS SP-71,

b. Check Valve Size: 3" thru 24" (Check Manufacturer Sizes)

2.5 IRON, CENTER-GUIDED CHECK VALVES

A. Class 125, Iron, Full Face; Wafer, Center-Guided Silent Check Valves with Metal Seat: (Type K).

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Stockham.

b. Milwaukee Valve Company.

c. Mueller Steam Specialty; a division of SPX Corporation. Model 101 MAP

2. Description:

   a. Standard: MSS SP-125.

   b. CWP Rating 200 psig @ 150˚F

   c. Check Valve Size: 1" thru 3"

B. Class 125, Iron, Globe, Center-Guided Silent Check Valves with Metal Seat (Type L):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Milwaukee Valve Company.

   b. Mueller Steam Specialty; a division of SPX Corporation. Model 105-MAP

   c. Spence Strainers International; a division of CIRCOR International.

2. Description:

   a. Standard: MSS SP-125.

      Valve Size 3" thru 24"

      CWP Rating:

      3 inch thru 12 inch 200 psig @ 150˚F

      14 inch thru 30 inch 150 psig @ 150˚F

   b. Valve Design: Spring loaded; silent check; globe style

C. Class 150, RS Bronze Gate Valves: (Type O).

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Crane Co.; Crane Valve Group; Crane Valves. Figure B-120.

   b. Milwaukee Valve Company. Figure 1151

   c. NIBCO INC.

   d. Powell Valves. Figure 2714

2. Description:

a. Standard: MSS SP-80, Type 2.

b. SWP Rating: 150 psig @ 406˚F

c. CWP Rating: 300 psig @ 150˚F End Connection Threaded

d. Valve Size 3/8" thru 3 inch

e. End Connection Threaded

2.6 IRON GATE VALVES

A. Class 125, OS&Y, Iron Gate Valves Bronze Trim: (Type Q).

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Stockham Division Figure G-623 (3" – 24")

c. Milwaukee Valve Company. Figure 2885A (3" – 12")

d. NIBCO INC.

e. Powell Valves. Figure 1793 Class 125, (3" thru 24")

2. Description:

a. Standard: MSS SP-70, Type I.

b. End Connection: Flange

c. Valve Size 3 thru 24 inch (See valve manufacturer's size limitations)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damages.

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

3.2 VALVE INSTALLATION

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

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

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

D. Install valves in position to allow full stem movement.

E. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.

2. Center-Guided Check Valves: In horizontal or vertical position, between flanges.

3. Lift Check Valves: With stem upright and plumb.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. Furnish and install valves shown on the drawings, specified herein and/or necessary for the control and easy maintenance of all piping and equipment. All valves shall be first quality of approved manufacture, shall have proper clearances, and shall be tight at the specified test pressure. Each valve shall have the maker's name or brand, the figure or list number and guaranteed ANSI working pressure cast on the body and cast or stamped on the bonnet, or shall be provided with other means of easy identification. All valves of one type (gate, ball, etc.) shall be the product of one manufacturer for that type of valve.

B. Valves shall be a minimum working pressure and materials as fittings specified for the service except as herein modified. All gate valves shall be suitable for repacking under pressure. Regardless of service, valves shall not be designated for less than 125 pounds per square inch steam working pressure.

C. Provide ball valves for shut-off wherever possible.

D. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball, butterfly valves.

2. Pump-Discharge Check Valves:

a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.

E. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

F. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2½ and Smaller: Threaded ends except where solder-joint valve-end option is required.

END OF SECTION 23 05 23

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SECTION 23 05 29 – HANGERS, SUPPORTS AND ACCESSORIES FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Pipe stands.
5. Equipment supports.

B. Related Sections:

1. Section 05 50 00 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Applicable Sections of Division 23.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design hangers and supports for piping and equipment in accordance with requirements in vibration section of Division 23 and obtain approval from authorities having jurisdiction.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawing Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Pipe stands.
3. Equipment supports.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.
4. Stainless steel hangers and pipe supports shall be used for piping located outdoors or indoors in area where systems are exposed to moisture environments.

C. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel orstainless steel.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

B. Back to Back channel loads shall be limited to the following:

1. 3 inch (4.1#) – 2,900 lbs up to 36 inches center to center
2. 3 inch (4.1#) – 1,700 lbs over 36 inches center to center
3. 4 inch (5.4#) – 5,100 lbs up to 36 inches center to center
4. 4 inch (5.4#) – 3,000 lbs over 36 inches center to center

2.3 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support piping.

B. Coordinated pipe stands mounting for piping on roof with the roofing system requirements in Division 07 titled "Thermal and Moisture Protection.

C. Single Pipe Stand (axial movement ¼ inch or less)

1. Pipe stand for horizontal piping mounted from floor or roof
2. Pipe Size Base Pipe Support

   3 ½ inch or less 2 ½ inch

3. Provide base flange to mount pipe stand to floor or roof.
4. Mount pipe support equal to MSS-SP- For exterior mounted pipe supports, pipe support shall be stainless steel or provide with coating to prevent corrosion.
5. 69 Type 101 cast iron stand to vertical pipe support.

D. Single Pipe Stand (axial movement greater than ¼ inch)

1. Assembly frame from vertical pipes or steel channels with cross bracing and horizontal members to support pipe.
2. Horizontal member shall be adequately sized to accommodate the pipe support and the weight of the pipe and contents.
3. For roof mounted piping or exterior mounted pipe, pipe stand shall be provide with coatings to protected against corrosion
4. Mount pipe on pipe support equal to MSS-SP-69 Type 44 or MSS-SP-69 Type 46 if vertical adjustment is required.
5. For exterior mounted pipe supports, pipe support shall be stainless steel or provide with coating to prevent corrosion. See MSS-SP -58 for coating requirements Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

E. Multiple-Pipe Stand (axial movement ¼ inch or greater)

1. Assembly frame from vertical pipes or steel channels with cross bracing and horizontal members to support pipes.
2. Horizontal member shall be adequately sized to accommodate the pipe support.
3. For roof mounted piping or exterior mounted pipe, pipe stand shall be provided with coatings to protected against corrosion
4. Mount pipe on pipe support equal to MSS-SP-69 Type 44 or MSS-SP-69 Type 46 if vertical adjustment is required for each pipe.
5. For exterior mounted pipe supports, pipe support shall be stainless steel or provide with coating to prevent corrosion.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

1. Pipe supports for curb mounted piping shall be as outline in paragraphs C, D & E.

2.4 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.5 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Install hangers supports for piping and equipment in accordance with the requirements schedules in Parts 2 & 3 of this section.

B. In all cases, attachments to structure shall be review by the Structural Engineer. Loads and details of attachment to structure shall be submitted to structural engineer for coordination and approval.

C. All required supports, hangers, anchors, guides shall be provided and installed by this contractor. Shop drawings shall be submitted indicating the following.
1. Methods of hanging or supporting all mechanical equipment & piping furnished by this trade.

2. Insert locations intended for the hanging of any mechanical equipment shall note the weight to be hung from each insert.
3. Insert locations intended for the hanging of piping over 5" or equipment shall also note the weight to be hung from each typical insert.
4. Where other methods are used, beam clamps or fish plates, for example, weights shall be similarly shown.
5. Multiple piping whether by other trades or not, if included on a trapeze type hanger furnished by this trade shall similarly indicate weights.
6. Note that mechanical equipment is not limited to pipe connected equipment, but includes fans, coils, etc.
7. Although piping under 6" need not be shown, furnish information upon request at any time during the course of the installation.
8. The indication of weights will not be waived unless there is reason to accept a general statement, approved in writing by the Architect and/or the Structural Engineer.
9. The structural engineer must approve the method of hanging before work is commenced.

D. All pipe supports shall be of type and arrangement as shown on "Pipe Hanger and Support Schedule" on drawings and hereinafter specified. They shall be so arranged as to prevent excessive deflection and avoid excessive bending stresses between supports.

E. All bracket clamp and rod sizes indicated in this specification are minimum sizes only. This trade shall be responsible for structural integrity of all supports. All structural hanging materials shall have a safety factor of 5 built in.

F. For copper tubing, supports shall follow schedule and specifications. Supports for uncovered lines shall be especially designed for copper tubing, and shall be of exact O.D. diameter of tubing and shall be copper plated.

G. Roller type supports shall be used for pipes subject to axial movement. They shall be braced so that movement occurs in roller rather than support rods.

H. Provide shields at hangers for cold insulated piping and saddles welded to pipe at hangers for hot insulated piping.

I. Provide all steel required for support of pipes and equipment other than steel shown on structural engineer's drawings.

J. All hangers on piping including clevis hangers, rods, inserts, clamps, stanchions, brackets, shall be dipped in Zinc Chromate Primer before installation.

K. All pipe supports shall be designed to avoid interferences with other piping, hangers, electrical conduits and supports, building structures and equipment.

L. Pipe hangers shall be connected to building structure as follows:

Building Structure Type	Pipe Support Method
Poured concrete floor slabs.	Galvanized steel inserts and/or fishplates of sufficient area to support twice the calculated dead load.
Building Structure Steel.	Beam Attachments, etc.
Concrete slabs where piping revisions are required and approved after slabs are poured.	Piping 3" and smaller may be supported at intermediate points by Phillips, or other approved 3/4" expansion bolts and shields, provided main supports are welded to structural steel and such main supports are welded to structural steel and such main supports are not less than 20 feet on centers.

M. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

N. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

O. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. For roof mounted piping, coordinate mounting with requirements outlined in Division 07 titled “Thermal and Moisture Protection”.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Division 07 Section titled "Roof Accessories" for curbs.

P. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

Q. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

R. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

S. Install lateral bracing with pipe hangers and supports to prevent swaying.

T. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

U. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

V. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

W. Insulated Piping:

1. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
2. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
3. Shield Dimensions for Pipe: Not less than the following:

a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor or roof.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

D. For roof mounted piping, coordinate mounting with requirements outlined in Division 07 titled “Thermal and Moisture Protection”

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal as required.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

B. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

C. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

D. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.

E. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment and outdoor applications.

F. Use copper-plated pipe hangers and stainless-steel attachments for copper piping and tubing.

G. Use padded hangers for piping that is subject to scratching.

H. Piping Hangers and Supports: Install Pipe Hangers and Supports as per the following schedule:

PIPE HANGER SCHEDULE & ACCESSORIES					
Designation	MSS-SP-69 Designation	Manufacturer Model			Cosentini Figure Designation (See Note1)
		Carpenter & Patterson	F & M	Grinnell	
Clevis Hanger	Type 1	268	282		1,2 & 3
Clevis Roller Hanger	Type 43	100	239	93	4,5 & 6
Two Rod Roller Hanger	Type 41	142	170	95	7,8 & 9
Ridge Trapeze	Type 59	371	See Note 3	See Note 3	10, 11 & 12
Cast Iron Roller Stand	Type 44	17	160	271	20, 21 & 22
Adjustable Cast Iron Roller Stand	Type 46	53	161	274	20, 21 & 22
Adjustable Steel Pipe Stanchion	Type 38	101/101U	291 See/ Note 2	259 See Note 2	23,24 & 25
Welded Steel Bracket (Light)	Type 31	69	See Note 3	See Note 3	19
Welded Steel Bracket (Medium)	Type 32	84	See Note 3	See Note 3	19
Welded Steel Bracket (Heavy)	Type 33	139	See Note 3	See Note 3	19
Single Bolt Riser Clamp	Type 8	126	241	261	40, 41 & 42
Double Bolt Riser Clamp	Type 42	124	See Note 3	See Note 3	40, 41 & 42
Three Bolt Pipe Clamp	Type 3	304	261	295	29
U-Bolt	Type 24	283	176	137	13, 14, 15, 31 and 23, 24 & 25 where adjustable steel pipe stanchion 101U is required
Beam Clamp	-	268	282	See Note 3	
Welded Beam Attachment	Type 22	113 A	See Note 3	66	Upper Attachment

PIPE HANGER SCHEDULE & ACCESSORIES					
Designation	MSS-SP-69 Designation	Manufacturer Model			Cosentini Figure Designation (See Note1)
		Carpenter & Patterson	F & M	Grinnell	
Welded Beam Attachment w/Bolt and Nut	Type 22	113B	251	66	Upper Attachment
Insert	-	-	-	-	Upper Attachment
Continuous Slotted Insert	-	-	-	-	Upper Attachment
Metal Deck Ceiling Bolt		143			
Pipe Shield (120)	Type 40	265 P			Insulated Pipe with Vapor Barrier Jacket
Pipe Shield (180)	Type 40	265 P			Insulated Pipe with Vapor Barrier Jacket
Pipe Shield (360)	Type 40	265 P			Insulated Pipe with Vapor Barrier Jacket
Pipe Saddle	Type 39	351 thru 357Z	170 & 1700 Series	180 Series	Insulated Pipe

I. The following schedule shall be used for hanger spacing and hanger rod size.

1. Where piping system includes concentrated loads (valves, strainers, air separators, etc.), provide additional hangers on either side of the concentrated load
2. Maximum weights on hanger rods assuming a maximum operating temperature of 450˚F shall be such that stress in tension shall not exceed 9,000 psi using root area of threaded portion of rod.

3. Minimum rod size for pipe size shall not be less than the rod size indicated in schedule regardless of load.

Pipe Hanging Spacing & Hanger Rod Schedule for Steel Piping		
Pipe Size	Maximum Hanger Spacing (Feet)	Minimum Hanger Rod Size (Diameter)
1/2 "	5	3/8"
3/4"	6	3/8"
1" & 1 1/4	7	3/8"
1 1/2"	9	3/8"
2"	10	3/8"
2 1/2"	11	1/2"
3"	12	1/2"
Pipe Hanging Spacing & Hanger Rod Schedule for Copper Piping		
Pipe Size	Maximum Hanger Spacing (Feet)	Minimum Hanger Rod Size (Diameter)
3/4"	5	3/8"
1" & 1 1/4	6	3/8"
1 1/2"	7	3/8"
2"	8	3/8"
2 1/2"	9	1/2"
3"	10	1/2"

J. Pipe Stanchion supports for horizontal pipes shall be as follows:

Pipe Size	Stanchion Support
2 ½ & 3 inch	2 ½ inch

K. Hanger-Rod Attachments: The following suggested Hanger-Rod Attachments are for information only. Final selection of Hanger-Rod Attachments shall be by the HVAC Contractor.

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.

L. Building Attachments: The following suggested Building Attachments are for information only. Final selection of Building Attachments shall be by the HVAC Contractor.

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam (MSS Type 20): For attaching to bottom flange of beams.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
7. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
8. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
9. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
10. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb (340 kg).
    b. Medium (MSS Type 32): 1500 lb (680 kg).
    c. Heavy (MSS Type 33): 3000 lb (1360 kg).

11. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
12. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
13. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

M. Saddles and Shields:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.

N. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

3.7 PANS AND DRAINS OVER ELECTRICAL EQUIPMENT

A. This contractor shall examine the drawings and in cooperation with the Electrical Trade confirm the final location of all electrical equipment to be installed in the vicinity of piping. Plan and arrange all overhead piping no closer than 6'-0" feet from a vertical line above electrical equipment, including but not limited to, main switchgear equipmentstarter, electric motors, switchboards, panelboards, or similar equipment. Piping is not permitted in Electric Equipment, Transformer, Switchgear, Elevator Equipment, Telephone Gear and Fire Pump Rooms.

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

C. Furnish gutters as follows:

1. Provide and erect a gutter of 16 ounce cold rolled copper or 18 gauge galvanized steel, under every pipe which is within 6'-0" from a vertical line to any motor, electrical controllers, switchboards, panel boards, or the like.

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

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

3.8 CONCRETE BASES

A. Concrete bases (including reinforcing and forms) shall be provided by the Contractor responsible for the work of Division 03.

B. Concrete bases shall be adequate to suit the footprint of the equipment but not less than 4 inches larger than the unit supported in both direction.

C. Concrete bases shall be a minimum of 4 inches high unless otherwise noted

D. HVAC Contractor (Work of Division 23) shall furnish shop drawings showing adequate concrete reinforcing steel details and equipment templates for all concrete bases, supports, anchor bolts and other appurtenances necessary for the proper installation of his equipment. Although the Contractor responsible for the work of Division 03 will complete all concrete work, all such work shall be shown in detail on the shop drawings, prepared by HVAC Contractor.

3.9 ERECTION OF METAL SUPPORTS AND ANCHORAGE

A. Comply with requirements in Division 05 "Metal." .

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

C. Refer to Division 23, Section 23 05 29 “Hangers and Supports for HVAC Piping and Equipment for additional requirement

D. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials.

E. Attach to substrates as required to support applied loads.

F. Field welding: Comply with requirements AWS D1.1 titled “Structural Welding Code.”

3.10 GROUTING

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

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

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

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

E. Packaging: Premixed and factory packaged.

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

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

H. Avoid air entrapment when placing grout.

I. Place grout to completely fill equipment bases.

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

K. Place grout around anchors.

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

3.11 CATWALKS, PLATFORMS, HANDRAILS AND LADDERS:

A. All catwalks, platforms, handrails and ladders shall be furnished and installed where shown on the drawings, specified or required to give safe access to all equipment needing regular servicing.

B. All catwalks, platforms, handrails and ladders shall comply with OSHA requirements.

C. As part of their work, this contractor shall engage the services of a licensed professional structural engineer with experience in the field of catwalk and platforms. He shall design and coordinate the catwalks, platforms, handrails, ladders and supports. The design shall be performed and certified (signed and sealed) by the licensed engineer.

D. Structural Performance: Design, engineer, fabricate and install the catwalks, platforms, handrails, ladders and supports to withstand the following structural loads without exceeding the allowable design working stress of the materials involved, including anchors and connections.

1. The catwalks and platforms shall be capable of withstanding the following loads applied as indicated:

   a. Uniformly distributed live load of 250 lbs. per sq. ft. and a concentrated load of 8,000 lbs, whichever produces the greater stress. Limit deflection to L/360 or 3", whichever is less.

2. The handrails and ladders shall be capable of withstanding the following loads applied as indicated:

   a. Uniformly distributed live load of 100 lb. per sq. ft. and a concentrated load of 300 lbs on an area of 4 square inches, whichever produces the greater stress. Limit deflection to L/360 or 3", whichever is less.

3. Design of structural steel shall be based upon a unit working tensile stress of 20,000 psi and shall conform to specifications of AISC, ACI, ASTM and OSHA.

4. The catwalks, platforms, handrails, ladders and supports shall be capable withstanding the seismic loads as outlined in another section of this work.

E. All catwalks, platforms, handrails, ladders, supports and structural members shall be galvanized steel.

F. Fabricate cut-outs in grating sections for penetrations of sizes and at locations indicated and as required to accommodate the installation of the work. Cut openings neatly and accurately to size: edge-band openings with bars having a thickness not less than overall grating thickness at contact points.

G. Wherever gratings are pierced by pipes, ducts and/or structural members, cut openings neatly and accurately to size and weld a steel strap collar not less than 1/8" thick to the cut ends.

H. The stringers shall be formed of galvanized steel channels. Floor gratings shall be made of 1 in. x 2 in. galvanized steel bars assembled on edge with a clear space between bars of not more than 3/4 in. The bars shall be welded to stringers. Supplementary steel members shall be attached to building structural members with 2 in. x 2 in. x 1/4 in. clip angles or 1/4 in. steel plates. Suspension angles shall be welded directly to stringers.

I. Catwalks and platforms shall be constructed with galvanized steel stringers supported with structural supports from below and provided with galvanized steel floor grating. Structural supports shall be anchored to floor construction, as required to meet structural loads as detailed above. Any additional structural members required to support the catwalk or platform and to make the connections herein specified shall be furnished and installed by this contractor.

J. The stringers shall be formed of galvanized steel channels. Floor gratings shall be made of 1 in. x 2 in. galvanized steel bars assembled on edge with a clear space between bars of not more than 3/4 in. The bars shall be welded to stringers. Supplementary steel members shall be attached to building structural members with 2 in. x 2 in. x 1/4 in. clip angles or 1/4 in. galvanized steel plates. Suspension angles shall be welded directly to stringers.

K. Railings: Railings shall be provided on both sides of catwalks and platforms (except within 3 in. of a wall) and on both sides of ladders. They shall be constructed with 1-1/2 in. standard weight galvanized steel pipe. Vertical members shall be not more than 8 ft. apart. Steel angles for suspension of catwalks may be vertical members of the railing.

L. The catwalk railing shall consist of two horizontal members. The upper horizontal member shall be 42 in. above walkway floors or the nosing of treads; the other member shall be located at approximately half of this height. Where openings in railings are provided for portable ladder, two slack chains shall be installed across the openings in place of the rails, one end of each to be attached by a hook.

M. Toe Boards: Steel toe boards not less than 4 in. high and at least 3/16 in. thick galvanized steel plate shall be provided on both sides of all catwalks and platforms located 8 ft. or more above the nearest floor and at the edge around openings. Toe boards shall be welded to, and centered between each railing post.

N. Ladders: Galvanized Steel Ladders shall be provided where shown on the drawings and as required to provide full access to all platforms and catwalks. Ladders shall comply with requirements of ANSI A14.3. Ship ladders shall be constructed with galvanized steel plate stringers and floor grating treads.

O. Railings, consisting of two (2) sloping members shall be provided for all ladders. Railings shall be as described above.

P. Stringers shall be set at an angle of 60 with the floor unless otherwise shown and shall be bolted to the channel stringers. Treads shall be of the same construction as walkway floor gratings and shall be attached to stringers with 1-1/4 in. x 1-1/4 in. x 1/4 galvanized in steel angles using 3/8 in. machine bolts.

Q. Vertical ladders shall be constructed using 1-1/2 in. x 3/8 in. galvanized steel side bars spaced 18 in. apart and 5/8 in round steel rungs spaced 12 in. apart. Rungs shall be tapered on ends and securely welded into the side bars.

R. Steel ladder members shall be attached to concrete floors with 2 in. machine bolts and expansion shields of the double clinch type.

S. Provide ladder safety cages.

T. All metal parts of catwalks, platforms and ladders shall be given a shop coat of red and linseed oil paint. All steel work shall be given a final coat of Rustoleum enamel.

U. Project Conditions: Check actual locations of walls and other construction to which catwalks, platforms and ladders must fit, by accurate field measurements before fabrication. Show recorded measurements on final shop drawings.

W. Submittals:

1. Plans, elevations, sections and details of metal fabrications and their connections.

2. In addition to the coordination requirements specified elsewhere in the contract documents, it shall be the responsibility of this contractor to confirm all dimensions and structural details based on the latest architectural and structural drawings relating to column, beam or wall locations or any other obstructions that must be accommodated as part of the catwalks, platforms and ladders or to provide proper clearances.

3. Certification that the catwalks, platforms, handrails and ladders have been designed, engineered and fabricated to meet the structural performance requirements (design loads) as specified herein. Certification shall be signed and sealed by the qualified professional engineer responsible for their preparation whose services are engaged by the manufacturer and/or fabricator.

END OF SECTION 23 05 29

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SECTION 23 05 47 - VIBRATION CONTROLS FOR MECHANICAL/ELECTRICAL SYSTEMS (NON-SEISMIC)

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section includes requirements for the vibration isolation controls for this Division's equipment and systems and installation within, on or outside the Building as herein specified.

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

C. Description of Work:

1. Provide a complete system of vibration isolation for systems and equipment as specified herein, and as needed for a complete and proper installation.

2. Provide vibration isolation systems for every System as shown and specified per Contract Documents.

3. The work of this section includes, but is not limited to, the following:

a. Vibration isolation elements for ductwork (if required), conduit, piping, equipment, systems, etc. as herein specified

b. Equipment isolation bases as herein specified

c. Piping flexible connections

D. This specification is part of the HVAC contracts.

E. It shall be understood that the requirements of this section are for the support, fastening, and isolating of equipment, components, ductwork, piping and conduit work. Nothing on the drawings or specifications shall be interpreted as a reason to waive the requirements of this wind load design section.

F. All outdoor equipment, including grade and roof mounted components shall comply with applicable code and section covering "wind loading". There shall be no decrease of the effects of wind load on a component due to other structures or components acting as blocks or screens.

G. Wind load and isolation materials shall be the certified products of the same manufacturing group and shall be certified by that group.

H. It is the intent of this Section of the Specification to keep all outdoor (roof and/or grade) HVAC, Plumbing, Fire Protection and Electrical Building System components in place and operational during a high wind event for buildings designated as "Essential Facilities" or sections of the building designated as an "Essential Facility". For all other buildings, it is the intent of this Section of the Specification to keep all outdoor (roof and/or grade) HVAC, Plumbing, Fire Protection and Electrical "Life Safety and or High Hazard" Building System components in place and operational during a high wind event.

I. All such systems must be installed in strict accordance with wind codes, component manufacturer's and building construction standards. Whenever a conflict occurs between the manufacturers or construction standards, the most stringent installation practice shall apply.

J. This specification is considered to be minimum requirements for wind control consideration. Whenever a conflict occurs between the specifications and the code or within the specification or drawings themselves, the most stringent practice shall apply.

K. Any variation which results in non-compliance with the specification requirements shall be corrected by the contractor in an approved manner, at no additional cost.

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

1. Wind design requirements for outdoor equipment (components).

2. Certification of wind restraint designs and installation supervision.

3. Certification of attachment of housekeeping pads.

4. All equipment (components) requiring code compliance.

5. All inspection and test procedures for equipment (components) requiring code compliance.

6. All heating, ventilating and air conditioning systems within or outside of building that require vibration isolation and restraint, vibration isolation (only) and restraint (only). Equipment buried underground is included if essential to the building's functioning in the event of a wind event. Entry services to the building, up to but not including Utility connections, is part of this specification. Equipment listed below is typical. It is the intent of this specification section that all equipment that requires vibration isolation and restraint, vibration isolation (only) and restraint (only) is included as part of this specification. All systems that are part of the building in any way are referred to as components including but not limited to:

7. All heating, ventilating and air conditioning systems within or outside of building that require vibration isolation. It is the intent of this specification section that all equipment that requires vibration isolation is included as part of this specification. All systems that are part of the building in any way are referred to as components including but not limited to:

    a. AC Units

    b. Air Handling Units

c. Compressors

d. Ductwork (where required in Part 3)

e. Equipment Supports

f. Fans (all types)

g. Fire Alarm Panels

h. Generators

i. Pipe

j. Pumps (all types)

k. Risers

l. Rooftop Units

m. Transformers

n. Vibration Isolators

M. This project requires compliance with Wind requirements for equipment located outdoors (roof and/or grade) in:

1. American Society of Civil Engineers (ASCE 7-05)

2. Applicable State and Local Codes having jurisdiction

N. Contractor responsible for the work of this Division shall engage the services on an independent Licensed Professional Engineer in the State of New York, with a minimum of 10 years' experience in the field of equipment supports and wind restraint

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. In the event that this section conflicts with the isolation or seismic requirements of other sections, the more stringent criteria stated herein shall apply.

B. This Section is a part of each Section of this Division.

C. This Section is applicable to all systems, equipment, etc. shown on the Fire Protection Plumbing HVAC Electrical Contract Drawing associated with the work of this Division.

1.3 APPLICABLE PUBLICATIONS CODES AND STANDARDS

A. City, State and Local Codes (Code) (Having Jurisdiction)*

B. BOCA National Building Code/1996 (Code)

C. International Building Code

D. International Mechanical Code

E. International Plumbing Code

F. NFPA 70 - National Electric Code

G. American Society of Civil Engineers (ASCE 7-05)*

H. New York State Building Code

I. International Energy Conservation Code

J. NFPA 13 and 14 for Fire Protection System (Standard)*

K. American Society For Testing and Materials (ASTM) (Standard)*

L. International Conference of Building Officials (ICBO) (Standard)

M. American National Standard Institute (ANSI):*

N. Air Moving and Conditioning Association (AMCA):*

O. American Society of Mechanical Engineers (ASME):*

P. National Fire Protection Association (NFPA):*

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

R. Occupational Safety and Health Administration (OSHA).*

S. Underwriters Laboratories (UL).*

1.4 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and as specified in Division 01 Section "SUBMITTALS."

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

C. The manufacturer of vibration isolation and wind restraints shall provide submittals for products and materials as follows:

1. Descriptive Data:

a. Catalog cuts and data sheets on specific vibration isolators to be utilized showing compliance with the specifications.

b. An itemized list showing the items of equipment or piping to be isolated, the isolator type and model number selected, isolator loading and deflection and base and construction where applicable.

D. Shop Drawings:

1. Drawings showing equipment base constructions including dimensions, structural member sizes and support point locations.

2. Drawings showing details of suspension and support for ceiling hung equipment.

3. Drawings showing methods for isolation of pipes and ductwork piercing walls and slabs.

4. Concrete and steel details for bases, including anchor bolt locations.

E. Documents will not be accepted for review unless:

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

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

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

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

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

6. All documents relating to wind restraint shall be stamped, sealed and signed by Licensed Professional Engineer whose service were engaged by the Contractor responsible for the work of this Division.

1.5 QUALITY ASSURANCE

A. All vibration isolation and restraint devices (if required for wind consideration) shall be the product of a single manufacturer.

B. The following manufacturers will be reviewed for approval, provided their systems strictly comply with the design intent for performance, deflection and structural capacity of this specification.

1.	Vibration Mountings & Controls (VMCI)	Bloomingdale, NJ
2.	Korfund Dynamics Corp. (KDC)	Bloomingdale, NJ
3.	Amber Booth (AB)	Houston, TX
4.	Mason Industries Inc. (MII)	Hauppauge, NY
5.	Vibration Eliminator Co. Inc. (VECI)	Long Island City, NY
6.	Kinetics Noise Control (KNC)	Dublin, OH

C. Vibration isolation firms having a minimum of ten (10) years experience in designing and installing vibration isolation systems shall be qualified to provide the materials and installation required by this section. Project listings shall be provided including geographical location and a reference contact.

D. The installation of all vibration isolation units and hangers and bases, shall be under the direct supervision of the vibration isolation manufacturers' representative.

E. Manufacturer of vibration isolation and wind load (if required) control equipment shall have the following responsibilities:

1. Determine vibration isolation sizes and locations.

2. Provide vibration isolation as scheduled or specified.

3. Provide restraint systems for equipment and components subject to high wind per recommendation from Licensed Professional Engineer engaged by the Contractor responsible for the work of this Division.

4. Provide installation instructions and drawings to ensure proper installation and performance.

5. All provisions of Section titled, General Design & Performance Requirements.

F. Equipment manufacturers' substitution of internally or externally isolated equipment supplied by the equipment vendor, in lieu of the isolation specified in this Section, is acceptable provided all conditions of this Section are met.

1.6 All costs for converting to the specified vibration isolation shall be borne by the equipment vendor in the event of non-compliance with the preceding. DEFINITIONS

A. Essential Facilities (Subject to high winds)

1. Buildings and other structures that are intended to remain operational in the event of extreme environmental loading from wind.

a. All HVAC, Plumbing, Fire Protection & Electrical Systems/Components (subject to high winds) in a building designated as an “Essential Facility” shall be restrained to remain in place and operational. The Systems/ Components shall include but not be limited to:

(i) ADD LIST OF SYSTEM/COMPONENTS

b. For project where a limited area of the building has been designated an "Essential Facility", all HVAC, Plumbing, Fire Protection & Electrical System/Components serving the designated "Essential Facility" area (subject to high wind) shall be restrained to remain in place and operational including but not limited to:

(i) ADD LIST OF SYSTEM/COMPONENTS

B. Life Safety and High Hazard (Subject to high winds)

1. All systems (Life Safety) involved with the Fire Protection System of the building subject to high winds shall remain in place and operational including but not limited to:

a. ADD LIST OF SYSTEM/COMPONENTS

2. All systems (Life Safety and High Hazard) involved with the Plumbing System of the building subject to high winds shall remain in place and operational including but not limited to:

a. ADD LIST OF SYSTEM/COMPONENTS

3. All systems (Life Safety and High Hazard) involved with the Heating, Ventilating and Air Conditioning System of the building subject to high winds shall remain in place and operational including but not limited to:

a. ADD LIST OF SYSTEM/COMPONENTS

4. All systems (Life Safety and High Hazard) involved with the Electrical System of the building subject to high winds shall remain in place and operational including but not limited to:

a. ADD LIST OF SYSTEM/COMPONENTS

C. Other Mechanical/Electrical Systems (Subject to high wind)

1. Mechanical/Electrical Systems involved with the building subject to high wind shall remain in place

a. ADD LIST OF SYSTEM/COMPONENTS

D. Basic Wind Speed: The basic wind speed, in Miles per Hour (MHP), for determination of the wind loads, shall be per criteria in (ASCE7-16) or local code (if more severe). For projects located in special wind regions near gorges or mountain terrain, Local authorities having jurisdiction shall determine wind speeds. Wind load design shall be determined based on the procedure outlined in American Society of Civil Engineers ASCE-7-05 Section 6.5.4. In no event shall the wind speed for the wind load design be less 100 MPH.

E. Component: A non-structural part or element of an architectural, electrical, heating, ventilating and air conditioning (HVAC), plumbing or fire protection system within or without of a building system.

F. System or System/Component: Compete installation consisting of equipment, ductwork, piping, conduit, electrical raceways, etc. also called component or equipment described above.

G. Hurricane Prone Regions: Areas prone to hurricanes include the U.S. Atlantic Ocean, Gulf Coasts, Hawaii, Puerto Rico, Guam, Virgin Islands, and American Samoa where the wind speed is greater than 90 mph.

H. Wind-Borne Debris Region: Portions of hurricane-prone regions that are within 1 mile of the coastal mean high water line where the basic wind speed is 110 mph or greater, the wind speed for the site is 115 MPH per ASCE7-16.

1.7 GENERAL DESIGN AND PERFORMANCE REQUIREMENTS

A. General Design Requirements.

1. WIND CONSIDERATIONS: This project has wind design requirements as follows:

a. Wind load in hurricane and or wind-born debris regions have a building height less than 60 Feet.

B. General Design Performance Requirements

1. Wind Load Certification and Analysis

a. Calculations by a Licensed Professional Engineer (engaged by the Contractor responsible for the work of this Division) registered in the State the Project is located in substantiating the mounting system for wind restraint and recommended anchor bolts shall be submitted for review along with the shop drawings. Calculations for wind loads shall be based on winds load as specified herein. All analysis shall be stamped by the above referenced Licensed Professional Engineer.

b. Unless otherwise specified System/Components shall be restrained to resist wind force. Restraints shall maintain System/Components in a captive position. Restraint devices shall be designed to meet wind requirements as defined in Applicable Code or by local authorities having jurisdiction.

2. Design Wind Loads:

a. All outdoor mounted components shall be positively fastened to their supporting structure.

b. If equipment is dunnage mounted, positive attachment shall occur through welding or bolting of equipment to dunnage steel.

c. Loads and calculations shall be based on Applicable Code and/or local authorities having jurisdiction and related sections in American Society of Civil Engineers ASCE-7-05.

d. Where buildings are less than 60 feet in height, loads for roof mounted System/Components shall be based on American Society of Civil Engineers ASCE-7-05 Section 6.15.1.

e. Equivalent basic wind speed shall be based on Applicable Code and/or local authorities having jurisdiction.

f. In no event shall the basic wind speed for wind load design be less than 100 MPH.

g. In no event shall adjacent buildings, structures or screens be considered to diminish the calculated wind load or its effect on an outdoor component.

1.8 CONTRACTOR RESPONSIBILITIES AND APPROVALS

A. The Contractor responsible for the work of this Division shall provide (furnish and install) all vibration isolation systems for the equipment, ductwork, piping electrical raceways, bus duct, cable trays, etc. and if project requires wind considerations, shall provide (furnish and install) restraint systems in addition to vibration isolation systems.

B. The Contractor responsible for the work of this Division shall engaged the services of a Licensed Professional Engineer registered in the State the project is located to:

1. Analyze, calculate, select restraint system for systems/components listed in previous paragraph titled "Definitions" of this section, review and approve shop drawing and provide Site visit to review installation of restraint systems and provide inspection report.

1.9 MANUFACTURER RESPONSIBILITIES

A. The manufacturer of vibration isolation, wind restraint equipment shall, as part his work, engage the services of a Licensed Professional Engineer (registered in the State that the Project is located in), who shall have the following responsibilities:

1. Design the vibration isolation sizes and locations.

2. Provide ductwork (if required), piping and equipment isolation systems as to meet the requirements as specified herein.

3. Guarantee specified isolation system deflection.

4. Provide installation instructions, drawings and field supervision to assure proper installation and performance.

5. Provide restraint equipment where project requires wind consideration to meet forces determined by the Licensed Professional Engineer engaged by the Contractor responsible for the work of this Division.

1.10 MISCELLANEOUS

A. Housekeeping pads shall be sized to have a minimum of 6 inches (15 cm) of clearance all around the equipment or 12 bolt diameters, whichever is greater.

B. All components shall be positively attached to the building structure and be approved by the structural engineer. Positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double-sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure.

PART 2 - PRODUCTS

2.1 GENERAL

A. All vibration isolation and restraint systems (if project requires wind considerations) shall be the product of a single manufacturer. The manufacturer model numbers for the specified vibration isolation systems, restraint systems (if project requires wind considerations) and equipment bases is based on Vibration Mounting and Controls (VMC) and are the standard for acceptance. Vibration isolations systems, restraint systems (if project requires wind considerations) and equipment bases manufactured by the Manufacturers listed in Part 1 of this Section will be acceptable provided they fully comply with the requirements of the standard.

2.2 INSPECTION

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

1. Licensed Professional Engineer, engaged by the Contractor responsible for the work of this Division, shall inspect the completed installation and report in writing any installation errors improperly selected restraint devices or other faults that could affect the performance on the restraint system. Contractor shall submit a report to the Architect, including the Licensed Professional Engineer’s final report, indicating all restraint devices reported as properly installed or requiring correction, and include a report by the Contractor on steps taken to properly complete the restraint device work.

2.3 VIBRATION ISOLATION TYPES

A. Note that vibration isolation devices are included herein for coordination purposes only. Vibration isolation is specified under another section of this work.

B. Type A: Spring Isolator – Free Standing

1. Manufacturer: Vibration Mounting and Controls

a. Model AB

2. Spring isolators shall be free standing and laterally stable without any housing and complete with a molded elastomeric cup or ¼" elastomeric acoustical friction pad between the bottom of isolator and the support.

3. All mountings shall have leveling bolts that must be rigidly bolted to the equipment.

4. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load.

5. Springs shall have a minimum additional travel to solid equal to 50% of the operating deflection.

6. Springs shall have a ratio of horizontal stiffness to vertical stiffness of between 0.8 and 1.25.

7. Each spring isolator shall be designed and installed so that the ends of the spring remain parallel during and after the spring installation

8. Spring shall be laterally stable without housing, snubbers or guides.

9. Mounting shall include two hole rectangular steel baseplate with two holes for bolting to structure.

10. Springs shall be color-coded for identification of rated load capacity.

11. All isolators shall operate in the linear portion of their load versus deflection curve and have 50% excess capacity without becoming coil bound.

12. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height.

C. Type B: Restrained Spring Isolator VMC:

1. Manufacturer: Vibration Mounting and Controls

   a. Model MS

2. Housed spring mounting shall have characteristics as specified for Type "A" spring isolator

3. Housing shall be cast ductile iron, malleable cast iron or welded steel construction. Gray cast iron not permitted

4. Housing shall include vertical limit stops to prevent spring extension during weight changes or when equipment is exposed to uplift loads such as wind loads. Limit stops shall be out of contact during normal operation

5. Housing shall serve as blocking during erection.

6. Housing design shall provide a minimum of ¼ inch between restraining bolt and housing and spring to prevent interference with spring performance.

7. Housing shall have an adjusting bolt on top of spring compressing plate

8. Neoprene acoustical non-skid pad (minimum ¼ inch thick) shall be attached to bottom of base plate.

9. Housing shall include provisions to adjust the rebound plate and inspect the spring.

10. Base plate shall be rectangular and have bolts holes to allow for isolator to be bolted or welded to structure.

11. For projects with wind considerations, housing shall be designed to resist all wind forces.

D. Type C: Combination Spring/Elastomer Hanger Isolator (30° Arc Type)

1. Manufacturer: Vibration Mounting and Controls

a. Model: HRSA

2. Hanger Isolator shall be a 1 ¼ inch thick elastomeric element at top of hanger housing with resilient bushing projecting through housing in series with a steel spring.

3. Isolator housing shall be steel box design

4. Spring shall have characteristics as specified for Type "A" spring isolator and shall be seated in a steel washer reinforced elastomeric cup at bottom.

5. Elastomeric element and elastomeric cup shall have elastomeric bushing projecting through steel box

6. Spring diameter and hanger box lower hole design shall be large enough to permit hanger rod to swing through a 30° arc from side to side before contacting the rod bushing and short circuiting spring.

7. Isolator to be used to hanger ductwork utilizing flat iron duct straps shall include eye bolts at both ends.

8. Submittals shall include hanger drawing showing the 30° capability.

E. Type C-1 Combination Spring/Elastomer Hanger Isolator (30° Arc Type) (Pre-Positioning)

1. Manufacturer: Vibration Mounting and Controls

a. Model: HRSPA

2. Hanger isolator shall have characteristics as specified for Type "C" Hanger isolator except:

a. Hanger isolators design shall include a means of holding equipment, piping, etc. at fixed elevation during installation regardless of load changes and a means of transferring load to spring.

F. Type C-2 Combination Spring/Elastomer Hanger Isolator (30° Arc Type) (Pre-compressed)

1. Manufacturer: Vibration Mounting and Controls

a. Model: HRSA-PR

2. Hanger isolator shall have characteristics as specified for Type "C" Hanger isolator except:

   a. Hanger isolator spring shall be pre-compressed to specified deflection to support equipment, piping, etc. at fixed elevation during installation regardless of load changes.

   b. Hanger design shall include a release mechanism to free spring after installation is complete and the hanger is subjected to full load.

G. Type D: Elastomer Double Deflection Hanger Isolator

1. Manufacturer: Vibration Mounting and Controls

   a. Model: HR

2. Molded (minimum 1 ¼" thick) DuruleneTM element with projecting bushing lining the rod clearance hole. Static deflection at rated load shall be a minimum of 0.35".

3. Steel retainer box encasing elastomeric mounting capable of supporting equipment up to four times the rated capacity of the element.

H. Type E Combination Spring/Elastomer Hanger Isolator

1. Manufacturer: Vibration Mounting and Controls

   a. Model: HRS

2. Hanger isolator shall have characteristics as specified for Type "C" Hanger isolator except:

   a. 30° angularity not required for Hanger isolators

I. Type E-1 Combination Spring/Elastomer Hanger Isolator (Pre-positioning)

1. Manufacturer: Vibration Mounting and Controls

   a. Model: HRSP (pre-positioning)

2. Hanger isolator shall have characteristics as specified for Type "C" Hanger isolator except:

   a. 30° angularity not required for Hanger isolators

   b. Hanger isolator spring shall incorporate a means for supporting equipment, piping, etc. at fixed elevation during installation regardless of load changes and a means of transferring load to spring

J. Type E-2 Combination Spring/Elastomer Hanger Isolator (Pre-compressed)

1. Manufacturer: Vibration Mounting and Controls

   a. Model: HRS-PR (pre-compressed)

2. Hanger isolator shall have characteristics as specified for Type "C" Hanger isolator except:

   a. 30° angularity not required for Hanger isolators

   b. Hanger isolator spring shall be pre-compressed to specified deflection to support equipment, piping, etc. at fixed elevation during installation regardless of load changes.

   c. Hanger design shall include a release mechanism to free spring after installation is complete and the hanger is subjected to full load

K. Type F: Not used for Non-Seismic Projects

L. Type G: Pad Type Elastomer Isolator (Standard)

1. Manufacturer: Mason Industries

   a. Type L Maxiflex

2. One layer of 18" x 18" x ¾" thick elastomeric pad consisting of 2" square modules; "E-Z" cut for size required.

3. Load distribution plates shall be used as required.

4. Bolting required for seismic compliance. Elastomeric and duck washers and bushings shall be provided to prevent short-circuiting.

M. Type H: Pad Type Elastomer Isolator (High Density)

1. Manufacturer: Vibration Mounting and Controls

   a. Model: Fabriflex

2. Laminated multiple layers canvas duck & neoprene, maximum loading 1000 psi, minimum 2" thick.

3. Load distribution plate shall be used as required.

4. Bolting required for seismic compliance. Elastomeric and duck washers and bushings shall be provided to prevent short circuiting.

N. Type I: Thrust Restraints

1. Manufacturer: Vibration Mounting and Controls

   a. Model: TRK

2. Construction shall consist of a spring in series with a neoprene pad or cup, threaded rods, washers, nuts, back-up plates and steel angles.

3. Thrust restraint design shall allow for field conversion from compression to tension.

4. Spring shall have characteristics as specified for Type "A" spring isolator

5. Design of thrust restraint shall limit air handling equipment movement to ¼ inch and shall be installed in pairs.

6. Thrust restraints shall be installed on air handling equipment whose thrust exceeds 10% of air handling equipment weight.

O. Type J: Pipe Anchors

1. Manufacturer: Vibration Mounting and Controls

   a. Model: AG

2. Multi-directional pipe anchor consisting of steel sections in series with heavy duty duck and neoprene material assembled in a telescopic housing

3. Design of anchor suitable for restraint in both the horizontal and vertical direction and balanced in all directions.

4. Loads on material shall not exceed 500 PSI.

P. Type K: Pipe Guides

1. Manufacturer: Vibration Mounting and Controls

   a. Model: LD

2. Provide resilient pipe guide for vertical pipe riser between anchor supports.

3. Construction of pipe guide shall consist of a four side angle iron frame with double deflection neoprene mountings. Neoprene mounting will be connected to each side of the frame aligning with center-line of pipe riser.

4. Neoprene mounting shall be color-code for identify rated load capacity.

5. Clearance between pipe/pipe insulation as required for pipe movement but not less than ½ inch.

6. In lieu of pipe described above, a vertical sliding pipe guide design maybe provided

   a. Manufacturer: Mason Industries; model VSG

   b. Guide design two steel tubes (one inside the other) with a minimum ½ inch thick, 60-durometer elastomer in the space between the two tubes.

   c. Height of guide shall be factor preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and re-insertable to allow for selection of pipe movement.

d. Pipe guide vertical movement as required to meet project requirements or a minimum of ± 1 5/8 inches.

Q. Type L: Isolated Pipe Hanger System

1. Manufacturer: Vibration Mounting and Control

a. Model: CIH, CIR, TIH, PIH

2. Spring-flex hanger system consisting of consisting of a pre-compressed spring and elastomer isolation hanger combined with pipe support into a single assembly.

3. System shall consist of spring element with a lower steel spring retainer and an upper elastomer retainer cup with integral bushing to insulate the support rod from the isolator hanger.

4. Spring shall have characteristics as specified for Type "A" spring isolator

5. Elastomeric element with integral bushing located under steel spring retainer. Bushing design to insulate support rod from steel spring retainer.

6. Hanger shall hinged to allow for up to 30° misalignment between rod attachment to structure and isolation hanger.

7. Hanger shall be designed and constructed to support loads over three times the rated load without failure.

8. Systems shall be pre-compressed to allow for rod insertion and standard leveling.

9. Hanger system shall be suitable to replace standard clevis, single or double rod roller or double rod fixed support.

2.4 WIND RESTRAINT SYSTEMS

A. Licensed Professional Engineer (engaged by the Contractor responsible for the work of this Division) shall design, specify, review and approve shop drawings, inspect final installation and submit final report certifying that the installation conforms to requirements for either or both Wind restraint systems.

1. Licensed Professional Engineer shall review, make recommendations for modifications (if require) to equipment bases specified in a subsequent paragraph in Part 2 to meet either or both wind forces and anchorage requirements.

2.5 EQUIPMENT BASES

A. General

1. All curbs and roof rails are to be bolted or welded to the building steel or anchored to the concrete deck (minimum thickness shall be 4") for resisting wind load forces in accordance with the project location. (Fastening to metal deck is unacceptable).

2. All curbs and roof rails are to be bolted or welded to the building steel or anchored to the concrete deck (minimum thickness shall be 4"). (Fastening to metal deck is unacceptable).

B. Base Types

1. Type B-1: Integral Structural Steel Base

   a. Manufacturer: Vibration Mounting and Controls

      (i) Model: WFB

   b. Rectangular bases are preferred for all equipment.

   c. Where required to suit equipment, rectangular structural steel bases shall include built-in adjustable motor slide rails.

   d. All perimeter members shall be structural steel beams with a minimum depth equal to 1/12 of the longest dimension of the base.

   e. Base depth need not exceed 12" provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer.

   f. Height saving brackets shall be employed in all mounting locations to provide a minimum base clearance of 2".

2. Type B-2: Concrete Inertia Base

   a. Manufacturer: Vibration Mounting and Controls

      (i) Model: MPF/WPF

   b. Vibration isolation manufacturer shall furnish rectangular or “T” shaped welded or bolted modular steel concrete pouring forms for floating and inertia foundations.

   c. Bases shall have a minimum depth of 1/12 of the longest dimension of the base but not less than 6".

   d. The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity.

   e. Forms shall include a minimum concrete reinforcing consisting of ½" bars welded in place a maximum of 12" on centers running both ways in a layer 1 ½" above the bottom.

   f. Forms shall be furnished with steel templates to hold the anchor bolts sleeves and anchors while concrete is being poured.

   g. Height saving brackets shall be employed in all mounting locations to maintain a 2" minimum clearance below the base.

3. Type B-3: Restrained Spring Isolation Curb

   a. Manufacturer: Vibration Mounting and Controls

      (i) Model: P6100/P6200/P6300; Model per scheduled deflection requirements in Part 3

   b. Roof curb shall be custom designed to suit the approved roof-top unit. HVAC Contractor to provide details of the approved roof-top unit to manufacturer of the roof curbs and submit the shop drawings of the roof curb to the roof-top unit manufacturer for approval.

   c. Roof curb shall generally consist of but not be limited to:

      (i) An upper floating structural frame designed for continuous support of unit and captive to resiliently resist wind forces for the location of the project. Wind hold down to connect roof-top unit to upper structural rail.

      (ii) Top flashing to provide weather-tight installation

      (iii) Wood nailer strip

      (iv) Spring isolators shall have characteristics as specified for Type "A" spring isolator, be laterally stable, rest on ¼ inch thick elastomeric and be color coded for proper identification. Spring shall be mounted in an accessible waterproof spring pockets to allow for spring removable, replacement and curb/equipment level adjustment. Where required to accommodate an extended height curb, spring isolators shall be mounted on a spring stanchion designed to resist wind forces for the location of the project.

      (v) Spring pockets shall contain combination horizontal and vertical restraints in conjunction with ¼ inch thick neoprene rubber bushing designed to resist wind forces at location of project.

      (vi) Lower continuous structural rail designed to accept point spring loads transferred from the roof-top unit to the building structure. Lower structural rail shall include provisions to connect roof curb to building structure capable of resisting wind forces at project location.

      (vii) Design of equipment load transfer to building structure shall be through roof curb contact point only.

      (viii) Perimeter walls of curb shall be provided with an insulation support shield (expanded metal) suitable installation of 2 inches of roofing type board insulation.

(ix) Perimeter and duct connection of the upper structural frame shall include a continuous neoprene elastomeric air seal to prevent air infiltration or exfiltration. Design of air seal shall be such that air seal is not subject to failure or in the event of failure water will not leak into the curb.

(x) Provide reinforcing cross-bracing as required to support unit and resist wind forces.

(xi) Upper structural rail shall include duct supports to match unit supply and return duct connections and suitable for flexible connection of supply and return ductwork.

(xii) Hardware shall be plated and springs shall be powder coated or cadmium plated.

(xiii) Curb waterproofing shall be designed to meet all requirements of National Roofing Contractor Association (NRCA)

d. Height of roof curb shall be

(i) Minimum as required by Manufacturer to construct curb assembly

(ii) As specified on drawings.

(iii) As required to accommodate horizontal duct offset above roof of supply and return ductwork with the bottom of horizontal duct 6 inches above roof.

(iv) Curb Manufacturer to coordinate final height requirements with HVAC Contractor

4. Type B-3A: Restrained Spring Isolation Curb with Sound Package

a. Manufacturer: Vibration Mounting and Control

b. Model: P6100/P6200/P6300 with PFMA sound package

c. Application: Supply and Return ductwork shall make a flexible connection to sound isolation floor. Sound isolation floor to have supply and return duct openings with angle iron frame to matched to unit supply and return air openings. Provide air-tight connections between sound isolation floor openings and respective opening on unit.

d. Spring isolation curb shall be as describe for Type B-3 above except as follows:

(i) Upper structural rail shall include an angle iron frame welded to the upper rail capable of supporting a continuous sound isolation floor.

(ii) Sound isolation floor shall be a "double-walled" panel consisting of a heavy gauge galvanized (G-90) sheet metal capable of spanning width of unit with 4 inches acoustical liner. Panel shall be capable of supporting 20 psf not weighting more than 6psf. Sound isolation floor design shall provide an air-tight joint between panels.

(iii) Sound isolation floor shall be two (2) layers of 5/8 inch sheetrock. Sheetrock joints between layers shall be staggered and provided with a continuous seal of acoustical caulking.

5. Type B-3B: Restrained Spring Isolation Curb with Sound package

a. Manufacturer: Vibration Mounting and Control

b. Model: P6100/P6200/P6300 with RPFMA sound package

c. Application: Supply ductwork shall make a flexible connection to sound isolation floor. A frame return air opening shall be provided in the sound isolation floor and the area between sound isolation floor and roof shall be used as a return air plenum. Sound isolation floor to have supply and return duct openings with angle iron frame to matched to unit supply and return air openings. Provide air-tight connections between sound isolation floor openings and the respective opening on unit.

d. Spring isolation curb shall be as describe for Type B-3 above except as follows:

(i) Upper structural rail shall include an angle iron frame welded to the upper rail capable of supporting a continuous sound isolation floor.

(ii) Sound isolation floor shall be a "double-walled" panel consisting of a heavy gauge galvanized (G-90) sheet metal capable of spanning width of unit with 4 inches acoustical liner. Panel shall be capable of supporting 20 psf not weighting more than 6psf. Sound isolation floor design shall provide an air-tight joint between panels.

(iii) Sound isolation floor shall be two (2) layers of 5/8 inch sheetrock. Sheetrock joints between layers shall be staggered and provided with a continuous seal of acoustical caulking.

(iv) In lieu of expanded metal perimeter walls, curb shall be provided with Galvanized (G90) sheet metal double-walled panels with 2 inches of insulation with a minimum "R" value equal to 12.

(v) Provide a flexible membrane within the perimeter of the curb to provide air tight plenum seal.

e. Height of roof curb shall be adjusted so that the maximum velocity of the return air traveling through the cross sectional area between sound Isolation floor and roof is equal to or less than return air ductwork or as required in Type B-3 for horizontal duct off-sets above roof.

6. Type B-3C: Restrained Spring Isolation Curb with Sound package

   a. Manufacturer: Vibration Mounting and Control

   b. Model: P6100/P6200/P6300 with SRPFMA sound package

   c. Application: Frame supply and return air openings shall be provided in the sound isolation floor and the area between sound isolation floor and roof. Sound isolation floor to have supply and return duct openings with angle iron frame to matched to unit supply and return air openings. Provide air-tight connections between sound isolation floor openings and the respective opening on unit.

   d. Spring isolation curb shall be as describe for Type B-3 above except as follows:

      (i) Upper structural rail shall include an angle iron frame welded to the upper rail capable of supporting a continuous sound isolation floor.

      (ii) Sound isolation floor shall be a "double-walled" panel consisting of a heavy gauge galvanized (G-90) sheet metal capable of spanning width of unit with 4 inches acoustical liner. Panel shall be capable of supporting 20 psf not weighting more than 6psf. Sound isolation floor design shall provide an air-tight joint between panels.

      (iii) Sound isolation floor shall be two (2) layers of 5/8 inch sheetrock. Sheetrock joints between layers shall be staggered and provided with a continuous seal of acoustical caulking.

      (iv) In lieu of expanded metal perimeter walls, curb shall be provided with Galvanized (G90) sheet metal double-walled panels with 2 inches of insulation with a minimum "R" value equal to 12.

      (v) Provide a flexible membrane within perimeter of curb to provide air tight plenum seal and on both sides of plenum divider

      (vi) Provide an insulated plenum divider (full width of curb) to divide the area between sound isolation floor and roof into a supply plenum and return plenum. Construction of plenum divider same as perimeter wall for curb.

   e. Height of roof curb shall be adjusted so that the maximum velocity of the return air traveling through the cross sectional area between sound isolation floor and roof is equal to or less than return air ductwork or as required in Type B-3 for horizontal duct off-sets above roof.

7. Type B-4: Restrained Non-Isolated Curb

   a. Manufacturer: Vibration Mounting and Control

      (i) Model: P6000

   b. Non-isolated curb shall be as described for Type B-3 above except as follows:

(i) Upper structural rail shall not "float" but shall be unitized with the lower structural rail

(ii) Spring isolation not required

(iii) Curb shall be designed to meet the wind force required for the project location

8. Type B-4A: Restrained Non-Isolated Curb with Sound Package

a. Manufacturer: Vibration Mounting and Control

b. Model: P6000 with PFMA sound package

c. Application: Supply and Return ductwork shall make a flexible connection to sound isolation floor. Sound isolation floor to have supply and return duct openings with angle iron frame to matched to unit supply and return air openings. Provide air-tight connections between sound isolation floor openings and respective opening on unit.

d. Non-isolation curb shall be as describe for Type B-4 above except as follows:

(i) Upper structural rail shall include an angle iron frame welded to the upper rail capable of supporting a continuous sound isolation floor.

(ii) Sound isolation floor shall be a "double-walled" panel consisting of a heavy gauge galvanized (G-90) sheet metal capable of spanning width of unit with 4 inches acoustical liner. Panel shall be capable of supporting 20 psf not weighting more than 6psf. Sound isolation floor design shall provide an air-tight joint between panels.

(iii) Sound isolation floor shall be two (2) layers of 5/8 inch sheetrock. Sheetrock joints between layers shall be staggered and provided with a continuous seal of acoustical caulking.

9. Type B-4B: Restrained Non-Isolated Curb with Sound Package

a. Manufacturer: Vibration Mounting and Control

b. Model: P6000 with RPFMA sound package

c. Application: Supply ductwork shall make a flexible connection to sound isolation floor. A frame return air opening shall be provided in the sound isolation floor and the area between sound isolation floor and roof shall be used as a return air plenum. Sound isolation floor to have supply and return duct openings with angle iron frame to matched to unit supply and return air openings. Provide air-tight connections between sound isolation floor openings and the respective opening on unit.

d. Non-isolation curb shall be as describe for Type B-4 above except as follows:

(i) Upper structural rail shall include an angle iron frame welded to the upper rail capable of supporting a continuous sound isolation floor.

(ii) Sound isolation floor shall be a "double-walled" panel consisting of a heavy gauge galvanized (G-90) sheet metal capable of spanning width of unit with 4 inches acoustical liner. Panel shall be capable of supporting 20 psf not weighting more than 6psf. Sound isolation floor design shall provide an air-tight joint between panels.

(iii) Sound isolation floor shall be two (2) layers of 5/8 inch sheetrock. Sheetrock joints between layers shall be staggered and provided with a continuous seal of acoustical caulking.

(iv) In lieu of expanded metal perimeter walls, curb shall be provided with Galvanized (G90) sheet metal double-walled panels with 2 inches of insulation with a minimum "R" value equal to 12.

(v) Provide a flexible membrane within perimeter of the curb to provide air tight plenum seal.

e. Height of roof curb shall be adjusted so that the maximum velocity of the return air traveling through the cross sectional area between sound isolation floor and roof is equal to or less than return air ductwork or as required in Type B-3 for horizontal duct off-sets above roof.

10. Type B-4C Restrained Non-isolated Curb with Sound Package

a. Manufacturer: Vibration Mounting and Control

b. Model: P6000 with SRPFMA sound package

c. Application: Frame supply and return air openings shall be provided in the sound isolation floor and the area between sound isolation floor and roof. Sound isolation floor to have supply and return duct openings with angle iron frame to matched to unit supply and return air openings. Provide air-tight connections between sound isolation floor openings and the respective opening on unit.

d. Isolation curb shall be as describe for Type B-4 above except as follows:

(i) Upper structural rail shall include an angle iron frame welded to the upper rail capable of supporting a continuous sound isolation floor.

(ii) Sound isolation floor shall be a "double-walled" panel consisting of a heavy gauge galvanized (G-90) sheet metal capable of spanning width of unit with 4 inches acoustical liner. Panel shall be capable of supporting 20 psf not weighting more than 6 psf. Sound isolation floor design shall provide an air-tight joint between panels.

(iii) Sound isolation floor shall be two (2) layers of 5/8 inch sheetrock. Sheetrock joints between layers shall be staggered and provided with a continuous seal of acoustical caulking.

(iv) In lieu of expanded metal perimeter walls, curb shall be provided with galvanized (G-90) sheet metal double-walled panels with 2 inches of insulation with a minimum "R" value equal to 12.

(v) Provide a flexible membrane within perimeter of the curb to provide air tight plenum seal and on both sides of plenum divider

(vi) Provide an insulated plenum divider (full width of curb) to divide the area between sound isolation floor and roof into a supply plenum and return plenum. Construction of plenum divider same as perimeter wall for curb.

e. Height of roof curb shall be adjusted so that the maximum velocity of the return air traveling through the cross sectional area between sound isolation floor and roof is equal to or less than return air ductwork or as required in Type B-3 for horizontal duct off-sets above roof.

11. Type B-5: Isolated Equipment Supports (Wind)

a. Manufacturer: Vibration Mounting and Control

(i) Model: R7100/7200/7300; Model per scheduled deflection requirements in Part 3

b. Equipment Support shall be custom designed to suit the approved equipment. HVAC Contractor to provide details of the approved equipment to manufacturer of equipment support and submit the shop drawings of the equipment support to the equipment manufacturer for approval.

c. Equipment support shall generally consist of:

(i) An upper floating structural rail designed for continuous support of unit and captive to resiliently resist wind forces for project location. Wind hold down to connect equipment to upper structural rail.

(ii) Spring isolators shall have characteristics as specified for Type "A" spring isolator, be laterally stable, rest on ¼ inch thick elastomeric and be color coded for proper identification. Spring shall be mounted in an accessible water-proof spring pockets to allow for spring removable and replacement and equipment to be level. Spring pockets shall contain combination horizontal and vertical restraints in conjunction with ¼ inch thick neoprene rubber bushing designed to resist seismic and wind forces at project location.

(iii) Lower continuous structural rail designed to accept point spring loads transferred from the equipment to the building structure. Lower structural rail shall include provisions to connect roof curb to building structure capable of resisting wind forces at project location.

(iv) Design of equipment load transfer to building structure shall be through roof curb contact point only.

(v) Perimeter walls shall be CCA grade plywood to protect structural rails to allow for proper flashing of support to roof system.

(vi) Provide reinforcing cross-bracing as required to support unit and resist wind forces.

(vii) Hardware shall be plated and springs shall be powder coated or cadmium plated.

(viii) Curb waterproofing shall be designed to meet all requirements of National Roofing Contractor Association (NRCA)

12. Type B-6: Non-Isolated Equipment Support (Wind)

a. Manufacturer: Vibration Mounting and Control

(i) Model: P7000

b. Equipment Support shall be custom designed to suit the approved equipment. HVAC Contractor to provide details of the approved equipment to manufacturer of equipment support and submit the shop drawings of the equipment support to the equipment manufacturer for approval

c. Non-isolated equipment support shall be as described for Type B-5 above except as follows:

(i) Upper structural rail shall not “float” but shall be unitized with the lower structural rail

(ii) Curb shall be designed to meet the seismic and wind force required for the project location.

13. Type B-8 Isolation Roof Curb

a. Manufacturer: Vibration Mounting and Controls

(i) Model: AXR Model

b. Roof curb shall be custom designed to suit the approved roof-top unit. HVAC Contractor to provide details of the approved roof-top unit to manufacturer of the roof curbs and submit the shop drawings of the roof curb to the roof-top unit manufacturer for approval.

c. Roof curb shall generally consist of:

(i) An extruded aluminum upper floating structural frame designed for continuous support of unit

(ii) Spring isolators shall have characteristics as specified for Type "A" spring isolator, be laterally stable, rest on ¼ inch thick elastomeric and be color coded for proper identification. Springs shall be mechanically fastened, sized and positioned for uniform deflection over entire system. Springs shall be zinc plated

(iii) Lower continuous structural rail designed to accept point spring loads transferred from the roof-top unit to the building structure. Lower structural rail shall include provisions to connect roof curb to building.

(iv) A continuous flexible seal shall connect the upper and lower rails to provide a water and air tight seal

(v) A closed-cell neoprene gasket bonded to the top of the upper rail and bottom of lower shall provide and air and water tight seal.

2.6 FLEXIBLE CONNECTORS

A. Type FC-1: Flexible Stainless Steel Hose

1. Flexible connector shall be a corrugated stainless steel hose with a protective stainless braid wire jacket.

2. Protective Jacket; Single/double/triple braid as required to meet system pressure

3. Flexible connect 2 ½ inch and smaller shall be a male nipple; 3 inch and larger flanged

4. Flexible connector working pressure; working pressure shall match working pressure of the piping system at the point of installation. See Division 23; Section titled "Hydronic Piping" for working pressure requirements at point of installation.

5. Design pressure shall be a minimum of 1.5 times working pressure.

B. Type FC-2: Flexible Bronze for Refrigerant Application

1. Seamless flexible tin/bronze tubing (suitable for use with Freon type system) with a protective bronze braided wire jacket.

2. Protective jacket; Less than 2 inch inside diameter shall be single braid; protective jacket piping systems 2 inch and larger double braid.

3. End connection; male wrought copper (solder type)

4. Working Pressure; Minimum equal to or greater than refrigerant pressure for system installed in.

5. Design pressure shall be a minimum of 1.5 times working pressure.

C. Minimum length of flexible connector

Pipe Size (inches)	Connector length (inches)
½	9
¾	10
1	11
1 ¼	12
1 ½	13
2	14

D. Hoses shall be installed on the equipment side of the shut-off valves horizontal and parallel to the equipment shaft wherever possible.

PART 3 - EXECUTION

3.1 EXAMINATION

A. All areas that will receive components requiring vibration control shall be thoroughly examined for deficiencies that will affect their installation or performance. Such deficiencies shall be corrected prior to the installation of any such system.

B. All areas that will receive system/components requiring wind consideration shall be thoroughly examined for deficiencies that will affect their installation or performance. Such deficiencies shall be corrected prior to the installation of any such system/component.

C. Examine all "rough ins" including anchors and reinforcing prior to placement.

3.2 COMPONENT INSTALLATION, (General)

A. All vibration isolators and/or wind restraint (if required) systems must be installed in strict accordance with the manufacturer's written instructions and all certified submittal data.

B. Installation of vibration isolators and/or wind restraints (if required) must not cause any change of position of equipment, piping or ductwork resulting in stresses or misalignment.

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

D. The contractor shall not install any isolated equipment, piping, duct, conduit, etc. which makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beam, columns, studs and walls.

E. Coordinate work with other trades to avoid rigid contact with the building.

F. Over stressing of the building structure must not occur because of overhead support of equipment. Contractor must submit loads to the structural engineer of record for approval. General bracing may occur from flanges of structural beams, upper truss cords in bar joist construction and cast in place inserts or wedge type drill-in concrete anchors.

G. Vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not permitted.

H. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust in relation to the equipment weight. Horizontal thrust restraints shall be those described in the specification when horizontal motion exceeds 3/8."

I. Contractor responsibilities with respect to spring isolation curbs

1. Coordinate physical (height, width, length, weight, etc.) requirement with the roof curb manufacturer.

2. Coordinate size and location of unit supply and return openings

3. For spring isolation curbs Types B-3 & B-3A, Contractor shall carry the cost of furnishing and installing (by Contractor responsible for roofing system) 2 inches of rigid roof insulation around the perimeter of roof curb. Insulation shall be fastened to expanded metal in accordance with roof curb manufacturer recommendations.

4. For spring isolation curbs Types B-3B & B-3C, Contractor shall carry the cost of furnishing and installing (by Contractor responsible for roofing system) 4 inches of rigid roof insulation under the full “footprint” of Unit. In addition, Contractor shall seal the inside perimeter at the interface of the roof insulation and curb with a vapor barrier cement.

5. For spring isolation curbs Types B-3, B-3A & B-3B, insulate exterior of ductwork (supply and return) with 2 inches of Type D-2 board insulation from 6 inches below roof to underside of unit/sound isolation floor. See Division 23 Section titled “Duct Insulation” for insulation requirements.

6. For spring isolation curbs Types B-3B & B-3C, coordinate clearance within roof curb between the roof and underside for sound isolation floor to limit plenum velocity to a maximum of the return air duct velocity

7. Where supply and/or return ductwork exists from roof curb horizontally above roof, coordinate height of the roof curb to allow for the bottom duct to exist roof curb a minimum of 6 inches above roof with curb manufacturer.

8. Where drawings have a height requirement for roof curb, coordinate height with curb manufacturer.

J. Contractor responsibilities with respect to non-isolated curbs

1. Coordinate physical (height, width, length, weight, etc.) requirement with the roof curb manufacturer.

2. Coordinate size and location of unit supply and return openings

3. For spring isolation curbs Types B-4 & B-4A, Contractor shall carry the cost of furnishing and installing (by Contractor responsible for roofing system) 2 inches of rigid roof insulation around the perimeter of roof curb. Insulation shall be fastened to expanded metal in accordance with roof curb manufacturer recommendations.

4. For spring isolation curbs Types B-4B & B-4C, Contractor shall carry the cost of furnishing and installing (by Contractor responsible for roofing system) 4 inches of rigid roof insulation under the full "footprint" of Unit. In addition, Contractor shall seal the inside perimeter at the interface of the roof insulation and curb with a vapor barrier cement.

5. For spring isolation curbs installed on pitched roofs, furnish and installed steel stub support posts (varying heights to suit roof pitch) from curb manufacturer to allow roof curb to be set level. Steel stub support posts shall be welded to building structure and lower structural rail per curb manufacturer's recommendations to meet seismic requirements.

6. For spring isolation curbs Types B-4, B-4A & B-4B, insulate exterior of ductwork (supply and return) with 2 inches of Type D-2 board insulation from 6 inches below roof to underside of unit/sound isolation floor. See Division 23 Section titled "Duct Insulation" for insulation requirements.

7. For spring isolation curbs Types B-4B & B-4C, coordinate clearance within roof curb between the roof and underside for sound isolation floor to limit plenum velocity to a maximum of the return air duct velocity

8. Where supply and/or return ductwork exists from roof curb horizontally above roof, coordinate height of the roof curb to allow for the bottom duct to exist roof curb a minimum of 6 inches above roof with curb manufacturer.

9. Where drawings have a height requirement for roof curb, coordinate height with curb manufacturer.

K. All equipment, piping, etc. shall be mounted on or suspended from approved foundations and supports, all as specified herein, or as shown on the drawings.

L. All rigidly or resiliently installed equipment, piping, etc., shall be capable of accepting wind forces acting in a perpendicular direction on the equipment center of gravity without permanent displacement of the equipment from the installed position.

M. All concrete foundations and supports (and required reinforcing and forms) will be furnished and installed by Contractor responsible for the work of Division 03. However, this Contractor shall furnish shop drawings showing adequate concrete reinforcing steel details and templates for all concrete foundations and supports, and all required hanger bolts and other appurtenances necessary for the proper installation of his equipment. Although the Contractor responsible for the work of Division 03 will complete all concrete work, all such work shall be shown in detail on the shop drawings, prepared by this Contractor which drawings shall be submitted showing the complete details of all foundations including necessary concrete and steel work, vibration isolation devices, etc.

N. All floor-mounted equipment shall be erected on a minimum of 4" high concrete pads over the complete floor area of the equipment, unless specified to the contrary herein. Wherever hereinafter vibration eliminating devices and/or concrete inertia blocks are specified, these items shall, in all cases, be in turn mounted upon 4" high concrete pads unless specified to the contrary herein. These pads shall be integrally keyed to structural slab.

O. The vibration isolation systems shall be guaranteed to have the deflection indicated in the schedule in Part 3 of this section. Mounting sizes shall be determined by the mounting manufacturer, and the sizes shall be installed in accordance with the manufacturer's instructions.

P. All mounting systems including wind restraints exposed to weather and other corrosive environments shall be protected with factory corrosion resistance. All metal parts of mountings (except springs and hardware) to be hot dip galvanized. Springs shall be cadmium plated and neoprene coated. Nuts and bolts shall be cadmium plated.

Q. Each wind restraint, snubbing device or isolation mounting incorporating wind restraint shall be installed and/or adjusted to provide the minimum operating clearance in all directions to permit the operation of the equipment without objectional noise or vibration to any part of the building structure.

R. Provide all necessary supports for equipment furnished as part of the work of this Division. To meet the varying conditions in each case, these supports shall consists of pipe stands, steel angle or strap hangers, saddles, brackets, etc., as approved. All such supports shall have substantial flanges bolted to floor construction; hangers shall be supported from the framing as described herein above. Supports shall be properly located with reference to any supporting pads, legs, etc., of the equipment carried and must be of such number and so distributed as not to bring any undue strains to the equipment. All details shall be as approved.

S. Provide suitable brackets, pipe stands, piers or other supports for all various ductwork accessories and appurtenances, piping system accessories and appurtenances, electrical system accessories and appurtenances, etc. Also provide suitable supports for all tempering stacks, air filters, mixing and control dampers, etc., securely clamped to steel beams, column or bearing walls. All details of this work shall be as approved. Guarantee that the work as installed under this section of the specifications will not result in the transmission of objectionable noise or vibration to any occupied parts of the building, and take full responsibility for any necessary modifications of this equipment, or of the foundations and supports for the same, necessary to secure this result.

T. All vibration isolators and wind restraint (if required) systems must be installed in strict accordance with manufacturer’s written instructions and all certified submittal data.

U. Coordinate work with other trades to avoid rigid contact with building.

V. Correct, at no additional cost, all installations which are deemed defective in workmanship and material.

W. Where piping and conduits pass through walls, floor, or ceiling, the Contractor shall provide wall seals or resilient packed sleeves.

3.3 EQUIPMENT INSTALLATION

A. All equipment shall be provided with equipment bases and/or vibration isolation per Tables A through D.

B. Buildings, that require wind consideration, shall be provided with restraint systems to resist wind forces, in addition to the equipment bases and/or vibration isolation required in subparagraph "A" above. Restraint system shall be design, selected, specified, reviewed (shop drawing) and inspected by the Licensed Professional Engineer engaged by the Contractor responsible for the work of Division 23.

C. Place floor mounted equipment on 4" high concrete housekeeping pads properly sized and doweled or expansion shielded to the structure. Anchor isolators and/or bases to housekeeping pads. Concrete work is specified in Division 03 of the contract documents.

D. Additional Requirements

1. The minimum operating clearance under all isolated components bases shall be 2."

2. All bases shall be placed in position and supported temporarily by blocks or shims, as appropriate, prior to the installation of the equipment, isolators and restraints.

3. The equipment shall be installed on blocks to the operating height of the isolators. After the entire installation is complete and under full load including water, the isolators shall be adjusted so that the load is transferred from the blocks to the isolators. Remove all debris from beneath the equipment and verify that there are no short circuits of the isolation. The equipment shall be free to move in all directions, within the limits of the restraints.

3.4 PIPING AND DUCTWORK ISOLATION

A. Vibration Isolation of Piping

1. HVAC Water Piping

2. Fire Protection Systems Piping

a. No isolators required

B. Wind Restraint of Piping, Conduit, Bus Duct, Cable trays, etc.

1. Buildings, that require wind consideration, shall be provided with restraint systems to resist wind forces in addition to vibration isolation required in subparagraph titled “vibration isolation of piping” above. Restraint system shall be design, selected, specified, reviewed (shop drawing) and inspected by the Licensed Professional Engineer engaged by the Contractor responsible for the work of this Division.

C. Vibration Isolation of Ductwork

1. All discharge runs for a distance of 50' from the connected equipment shall be isolated from the building structure by means of Type E combination spring elastomer hanger or Type A floor spring isolators. Spring deflection shall be a minimum of 0.75".

2. All duct runs having air velocity of 1500 feet per minute (fpm) or more shall be isolated from the building structure by Type E combination spring elastomer hangers or Type A floor spring supports. Spring deflection shall be a minimum of 0.75"

3. Wind Restraint of Ductwork

a. Buildings, that require wind consideration, shall be provided with restraint systems to resist wind or forces in addition to vibration isolation required in subparagraph titled “vibration isolation of ductwork” above. Restraint system shall be design, selected, specified, reviewed (shop drawing) and inspected by the Licensed Professional Engineer engaged by the Contractor responsible for the work of Division 23.

3.6 FIELD QUALITY CONTROL, INSPECTION

A. Upon completion of installation of all vibration isolation devices, the local representative shall inspect the completed project and certify in writing to the Contractor that all systems are installed properly, or require correction. The Contractor shall submit a report to the Architect, including the representative's report, certifying correctness of the installation or detailing corrective work to be done.

3.7 EQUIPMENT VIBRATION ISOLATION SCHEDULES (NON-SEISMIC)

A. The following schedules (Tables A through D) are applicable to Systems/Components that are not required by Code to be seismically restrained.

1. Vibration isolator type, deflection and base type have been reviewed and approved by Project Acoustical Consultant.

B. Abbreviations applicable to Schedules (Tables A through D)

1. MISC. INFO. Miscellaneous Information

2. EQUIP. MTNG. Equipment Mounting

3. ISOL. TYPE Vibration Isolation Type

4. DEFL. Deflection

HVAC EQUIPMENT VIBRATION ISOLATION SCHEDULE TABLE A (NON-SEISMIC)								
EQUIPMENT LOCATION			SLAB ON GRADE OR BASEMENT SLAB ON GRADE			STRUCTURAL SLAB (SUSPENDED)		
Equipment Type	Misc. Info.	Equip. Mtng.	Isolation Type	Defl (Inches)	Base Type	Isolation Type	Defl (Inches)	Base Type
Air Handling Units (indoor)	--	Floor	B	0.75	--	B	1.5	--
		Ceiling	--	--	--	E	1.0	--
Condensers, Condensing Unit, Etc	--	Grade/ Roof	--	--	--	B	2.0 minimum	B-5
Axial Fans	--	Floor	B	0.75	--	B	See Equip Guide	--
	--	Ceiling	--	--	--	E -2	See Equip Guide	--
Plug Fans	Class 1 & 2	Ceiling	E-2	See Guide	--	E-2	See Equip Guide	--
Plenum Fans	Class 1	Floor	B	0.75	--	B	See Equip Speed Guide	--
	Class 2 & 3	Floor	B	0.75	--	B	See Equip Speed Guide	--
Centrifugal Fans Arrangement 1 & 3	Class 1	Floor	B	0.75	B-1	B	See Equip Speed Guide	B-1

HVAC EQUIPMENT VIBRATION ISOLATION SCHEDULE TABLE A (NON-SEISMIC)								
EQUIPMENT LOCATION			SLAB ON GRADE OR BASEMENT SLAB ON GRADE			STRUCTURAL SLAB (SUSPENDED)		
Equipment Type	Misc. Info.	Equip. Mtng.	Isolation Type	Defl (Inches)	Base Type	Isolation Type	Defl (Inches)	Base Type
	Class 2 & 3	Floor	B	0.75	B-2	B	See Equip Guide	B-2
	Class 1	Ceiling	--	--	--	E-2	See Equip Speed Guide	B-1
Centrifugal Fans Arrangement 9,10 & Vent Sets	Class 1	Floor	B	0.75	--	B	See Equip Speed Guide	B-1
	Class 2 & 3	Floor	B	0.75	B-2	B		B-2
	--	Ceiling	--	--	--	E-2		--
	--	Roof	--	--	--	--		B-5
Cabinet Fans	1 HP or Less	Floor	F	0.2	--	B	0.75	--
		Ceiling	--	--	--	E-2	0.75	--
	Greater Than 1HP	Floor	B	0.75	--	B	See Equip Speed Guide	--
		Ceiling	--	--	--	E-2	See Equip Speed Guide	--
Curb Mounted Equipment (non-isolated)	--	Roof	--	--	--	--	--	B-6
Non -isolated Equipment		Floor	--	--	--	--	--	--
Condensate Pumps	--	Floor				F	0.2	if Required

HVAC EQUIPMENT VIBRATION ISOLATION SCHEDULE TABLE A (NON-SEISMIC)								
EQUIPMENT LOCATION			SLAB ON GRADE OR BASEMENT SLAB ON GRADE			STRUCTURAL SLAB (SUSPENDED)		
Equipment Type	Misc. Info.	Equip. Mtng.	Isolation Type	Defl (Inches)	Base Type	Isolation Type	Defl (Inches)	Base Type
Fan Coil Unit (incremental)	--	Floor	--	--	--	--	--	--
	--	Ceiling	--	--	--	D	1.0	--
Unit Heaters	--	Ceiling	--	--	--	D	0.75	--
Cabinet Heater	--	Floor	--	--	--	--	--	--
	--	Ceiling	--	--	--	D	0.75	--
Roof Top Air Cooled Air Conditioning Unit	10 Tons or Less	Roof	--	--	--	--	1.5	See Note 3
	Greater than 10 Tons	Roof	--	--	--	--	2.0	See Note 3
Roof Top Air Handling Unit	--	--	--	--	--	--	1.0	B-5

EQUIPMENT SPEED GUIDE (MINIMUM ISOLATOR DEFLECTION) SCHEDULE EQUIPMENT LOWEST OPERATING SPEED (RPM)	DEFLECTION (INCHES)
Less than 400	3.5
401 t0 600	2.5
601 to 900	2.0
Greater than 900	1.0

Note: The Equipment Speed Guide is applicable to equipment in Table "A"

1. For equipment with the designation “See Guide,” use Equipment Speed Guide for required deflection.

2. Base Type B-5 (vibration isolated equipment) shall be used. Base Type B-6 (non-vibration isolated equipment) shall be used.

3. Based Type B-3 shall be used for Roof Top Air Cooled Air Conditioning Units for projects where the roof deck under the unit is either a concrete slab of concrete over a metal deck and supply and return ductwork is directly connected to unit.

4. The following base types shall be used for Roof Top Air Cooled Air Conditioning Units for projects where there is only a metal deck under the unit

   a. Base Type B-3A for unit where the supply and return ductwork is directly connected to unit.

   b. Base Type B-3B for units where the supply ductwork is directly connected to the unit and the area below the unit and above the roof deck is used as a return air plenum.

   c. Base Type B-3C for units where the area below the unit and above the roof deck is used as supply air plenum and a return air plenum.

5. Based Type B-4 shall be used for Roof Top Air Cooled Air Conditioning Units for projects where vibration isolation of unit is not required and the roof deck under the unit is either a concrete slab of concrete over a metal deck and supply and return ductwork is directly connected to unit.

6. The following base types shall be used for Roof Top Air Cooled Air Conditioning Units for projects where vibration isolation of unit is not required and there is only a metal deck under the unit.

   a. Base Type B-4A for unit where the supply and return ductwork is directly connected to unit.

   b. Base Type B-4B for units where the supply ductwork is directly connected to the unit and the area below the unit and above the roof deck is used as a return air plenum.

   c. Base Type B-4C for units where the area below the unit and above the roof deck is used as supply air plenum and a return air plenum.

7. Equipment (for example air handling) not suitable for point support that requires external vibration isolation, provide Type B-1 equipment base for the entire unit. For deflection see “equipment Speed Guide Schedule” based on lowest operating speed.

8. Deflections indicated are minimum at actual load. Actual spring deflection shall be selected for manufacturer’s nominal deflection (1, 2, 3, 4 & 5 inches) spring series. Equipment speed (RPM) is defined as lowest operating speed.

9. Curb mounted fans that require a floor area of less than 9.0 square feet are excluded.

10. For equipment with multiple motors, horsepower classifications apply to largest single motor.

PLUMBING EQUIPMENT VIBRATION ISOLATION SCHEDULE TABLE B (NON-SEISMIC)								
EQUIPMENT LOCATION			SLAB ON GRADE OR BASEMENT SLAB ON GRADE			STRUCTURAL SLAB (SUSPENDED)		
Equipment Type	Misc. Info.	Equip. Mtng.	Isolation Type	Defl (Inches)	Base Type	Isolation Type	Defl (Inches)	Base Type
Domestic Water Heaters	--	Floor	--	--	--	--	--	--

ELECTRICAL EQUIPMENT VIBRATION ISOLATION SCHEDULE TABLE C (NON-SEISMIC) INSTALLATION ATTACHMENT POINT								
EQUIPMENT LOCATION			SLAB ON GRADE OR BASEMENT SLAB ON GRADE			STRUCTURAL SLAB (SUSPENDED)		
Equipment Type	Misc. Info.	Equip. Mtng.	Isolation Type	Defl (Inches)	Base Type	Isolation Type	Defl (Inches)	Base Type
Transformer (Dry Type)	Up to 150 KVA	Floor	--	--	--	B	1	--
		Ceiling	--	--	--	E-2	1	--
Emergency Generator	All Sizes	Floor	B	1	--	--	--	--
Uninterruptible Power Supply (UPS)	All Sizes	Floor	F	0.2	--	B	2.0	--
Transformer (Dry Type)	Greater than 150 KVA	Floor	--	--	--	B	1	--

END OF SECTION 23 05 47

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SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Stencils.
6. Valve tags.
7. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Lamacoid Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.

2. Letter Color: White

3. Background Color: Black.

4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering. (1/2" letters for rooftop equipment, ¼" letters for above ceiling equipment)

7. Fasteners: Stainless-steel rivets or self-tapping screws.

8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Red.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

J. Signs and labels shall meet requirements of ASTM 709, Type I.

K. Include p-touch labels for equipment directly underneath on ceiling grid and on thermostat.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction conforming with ASME A13.1.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.

2. Lettering Size: At least 1-1/2 inches (38 mm) high.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic (or stickers) labels for mechanical engraving, 1/16 inch (1.6 mm) thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Black.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.

2. Lettering Size: At least 1-1/2 inches (38 mm) high.

3. Conform with requirements of ASTM A 13.1.

2.5 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches (32 mm) for ducts; and minimum letter height of 3/4 inch (19 mm) for access panel and door labels, equipment labels, and similar operational instructions.

1. Stencil Material: Fiberboard.

2. Stencil Paint: Exterior, gloss, alkyd enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.

3. Identification Paint: Exterior, alkyd enamel in colors according to ASME A13.1 unless otherwise indicated.

2.6 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.

1. Tag Material: Brass, 0.032-inch (0.8-mm) minimum thickness and having predrilled or stamped holes for attachment hardware.

2. Fasteners: Brass S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.7 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches (75 by 133 mm) minimum.

2. Fasteners: Brass grommet and wire.

3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels complying with ASME A13.1, on each piping system.

1. Identification Paint: Use for contrasting background.

2. Stencil Paint: Use for pipe marking.

B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.

3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.

4. At access doors, manholes, and similar access points that permit view of concealed piping.

5. Near major equipment items and other points of origination and termination.

6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.

7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Pipe Label Color Schedule:

1. Refrigerant Piping:

a. Background Color: Blue.
b. Letter Color: White.

3.4 DUCT LABEL INSTALLATION

A. Install plastic-laminated duct labels with permanent adhesive on air ducts in the following color codes:

1. BlueFor exhaust-, outside-, relief-, return-, and mixed-air ducts.

2. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch (25 mm) high is needed for proper identification because of distance from normal location of required identification.

C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet (15 m) in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:
a. Refrigerant: 2 inches (50 mm), round.

2. Valve-Tag Color:
a. Refrigerant: Natural.

3. Letter Color:
   a. Refrigerant: Black.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 23 05 53

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SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SECTION INCLUDES

A. Testing, adjusting, and balancing of Air Systems.

B. Measurement of final operating conditions of HVAC Systems.

C. Sound measurement of equipment operating conditions.

D. Vibration measurement of equipment operating conditions.

E. Measurement of the IAQ after the completion of the final balancing.

1.3 SCOPE OF WORK

A. General:

1. Testing, adjust and confirm design airflows rates, pressure drops, pressures, temperatures and heat transfer performance for HVAC systems, including, but not limited to supply air, return air and exhaust air systems, including all associated coils, fans, dampers, diffusers, terminal devices, and accessories.

2. Provide all necessary labor, materials, products, equipment and services to balance and test all HVAC systems, to verify conformance to specified quantities, and to the design intent of the mechanical system and for the testing of all the fire safety systems.

3. Cooperate with all other trades, including, but not limited to, building controls, fire alarm, sheetmetal and piping sub-contractors to ensure the Work is carried out without interference to other Work.

4. Provide openings required for pitot tube traverses. After balancing, close openings with removable gasketed plugs. Submit samples of proposed plugs for approval.

5. Conduct routine inspections during the mechanical systems installation and report on poor ductwork installation (likely to produce abnormal leakage), poor piping installation, poor placement of dampers, and any circumstance which will encumber the balancing of the mechanical systems.

6. Review Drawings and Specifications and ensure that adequate provisions are made in the mechanical installation to facilitate the balancing of all air systems; make recommendations to the Architect/Engineer where additional measures may be required.

7. Include all items of labor, materials, products, equipment and devices required to comply with such standards and codes in accordance with the contract documents to balance all air and hydronic systems, to verify conformance to specified quantities and to the design intent of the mechanical system. Where quantities, sizes or other requirements indicated on the drawings or herein specified are in excess of the standard or code requirements, the specifications and drawings shall govern.

1.4 REFERENCES

A. ASHRAE - Standard 111 - 1988 Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air Conditioning, and Refrigeration Systems.

B. ASHRAE - 1987 HVAC Systems and Applications Handbook: Chapter 57, Testing, Adjusting and Balancing.

C. AABC- National Standards for Total System Balance.

D. NEBB - Procedural Standards for Testing, Balancing and Adjusting of Environmental System.

E. SMACNA - HVAC System Testing, Adjusting and Balancing.

F. Sheet Metal Industry - Certification of Testing, Adjusting and Balancing Technicians.

1.5 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An entity engaged to perform TAB Work.

F. Systems testing, adjusting, and balancing is the process of checking and adjusting all the building environmental systems to produce the design objectives. It includes:

1. The balance of air distribution;

2. Adjustment of total system to provide design quantities; verification of performance of all equipment and automatic controls;

3. Sound and vibration measurement.

4. IAQ measurements

G. Test: To determine quantitative performance of equipment.

H. Adjust: To regulate the specified air patterns at the terminal equipment (e.g., reduce fan speed, throttling).

I. Balance: To proportion flows within the distribution system (submains, branches, and terminals) according to specified design quantities.

J. Procedure: Standardized approach and execution of sequence of work operations to yield reproducible results.

K. Report forms: Test data sheets arranged for collecting test data in logical order for submission and review. These data should also form the permanent record to be used as the basis for required future testing, adjusting, and balancing.

L. Terminal: The point where the controlled fluid enters or leaves the distribution system. These are supply outlets on air terminalsand exhaust or return inlets on air terminals such as registers, grilles, diffusers, and hoods.

M. Main: Duct containing the system's major or entire fluid flow.

N. Submain: Duct containing part of the systems' capacity and serving two or more branch mains.

O. Branch main: Duct serving two or more terminals.

P. Branch: Duct serving a single terminal.

1.6 ACTION SUBMITTALS

A. LEED Submittals:

1. Air-Balance Report for Prerequisite IEQ 1: Documentation of work performed for ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

2. TAB Report for Prerequisite EA 2: Documentation of work performed for ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

B. Procedures: Furnish submittals in accordance with the general requirements of the Contract Documents.

C. Activity Programs: The Air Balance contractor shall prepare and submit for approval a detailed activity program. The program shall be in accordance with the overall Construction Schedule.

1. Specific requirements included within the activity program shall be:

a. Required dates for the acceptance of system/equipment from the installing contractor "ready for balance".
b. Required Periods for the individual system balancing.
c. Requirements for attendance from the installing contractor and their suppliers.

2. Activity Programs shall be prepared for each major system and/or specific item of equipment.

D. Certified Test Reports: Furnish test results and a schematic layout for each system, certified by the Contractor. Six completed copies including schematic layouts, shall be submitted to the Owner. Balancing report submitted shall list each grille, register and diffuser associated with each system, giving numerical identification (including room number or area name), design quantity, final quantity, etc., and design power requirements for all supply and exhaust fans and actual operating conditions listing RPM, volts, amps, kw, etc., in accordance with AABC/NEBB/TABB test report forms. Include identification and types of instruments used and their most recent calibration date with test reports.

1. General

a. Provide a complete balancing report in 3-ring binder manuals. Report should include contents, page and index tabs and cover identification at front and side.
b. Include types, serial number and dates of calibration of test instruments. (Submit calibration certificates).
c. Record test data on a sepia made from the latest available revised set of mechanical drawings and submit six (6) copies upon completion of the balancing contract.
d. Install at each piece of mechanical equipment a "Data Register" showing significant operating temperatures, pressures, amperes, voltage frequency, motor KW, FLA, belt size/model number and sheave size. "Data Register" to be enclosed in a plastic holder securely attached to the equipment or to a wall in the adjacent area.
e. Submit with report, fan curves with operating conditions plotted. Submit grille and diffuser shop drawings and diffusion factors.
f. Submit with the report schematics of all the air systems.

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 45 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 45 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. Certified TAB reports.

E. Sample report forms.

F. Instrument calibration reports, to include the following:

1. Instrument type and make.

2. Serial number.

3. Application.

4. Dates of use.

5. Dates of calibration.

1.8 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC, NEBB, or TABB. The entity shall be an independent testing, adjusting and balancing entity, single source of responsibility to test adjust and balance building systems to produce design objectives. Services shall include checking installation for conformity to design, measurement and establishment of capacities of the mechanical systems as required to meet design specifications and recording and reporting the results. The entity shall have at least one Professional Engineer registered in the State in which the services are to be performed and certified by NEBB or AABC as a Testing and Balancing Engineer.

1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC, NEBB or TABB.

2. TAB Technician: Employee of the TAB contractor and who is certified by AABC, NEBB or TABB as a TAB technician.

B. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.

2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

C. TAB Report Forms: Use standard TAB contractor's forms approved by Owner Construction Manager or Commissioning Authority.

D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

F. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

G. The air balance agency shall provide proof of having at least 5 years testing, adjusting and balancing experience, as well as having successfully completed at least five projects of similar size and scope.

H. The work must be performed by a Certified Testing, Adjusting and Balancing Technician who may be assisted by other TAB Technicians under the supervision of the TAB Field Supervisor. The Certified Testing, Adjusting and Balancing Technician is responsible for:

1. Procedures to be followed
2. Accuracy of all testing
3. Integrity of recorded data
4. Entering all data and reporting any abnormal or notable conditions on the report forms
5. Initialing and dating each sheet

I. The General Section of the Balance Report shall include the names, signatures, and registration numbers of the Technicians who were assigned to the project. The Balancing Report shall also include the signature and registration number of the Professional Engineer and a statement that he has reviewed and approve the report.

J. Codes and Standards:

1. NEBB: "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."
2. AABC: "National Standards For Total System Balance".

K. Contractor's Quality Assurance Responsibilities: This Contractor is solely responsible for quality control of the Work. Comply with the general requirements of the contract.

L. IAQ Testing Agency Qualifications:

1. The testing and balancing agency shall employ the services of an independent IAQ testing agency to test the building air systems identified above, to produce an IAQ report.
2. In conjunction with the testing and balancing agency, the IAQ testing agency's services shall include checking installations for conformity to design, measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications and recording and reporting the results.
3. The independent testing agency shall be certified by a National entity jurisdiction in IAQ testing disciplines required for this project and having at least one Professional Engineer registered in the State in which the services are to be performed.
4. The testing agency shall provide proof of having at least 5 years testing experience, as well as having successfully completed at least five projects of similar size and scope.
5. The work must be performed by a Certified Technician who may be assisted by other Technicians. The Certified Technician is responsible for:

a. Procedures to followed
b. Accuracy of all testing
c. Integrity of recorded data
d. Entering all data and any abnormal or notable conditions in report forms
e. Initialing and dating each sheet

6. The General Section of the Report shall include the names, signatures, and registration numbers of the Technicians who were assigned to the project.

1.9 PROJECT CONDITIONS

A. General: Do not proceed until systems requiring testing, adjusting and balancing are clean and free from debris, dirt, and discarded building materials.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

C. Air balance and testing shall not begin until system has been completed and is in full working order. The mechanical contractor shall put all heating, ventilating and air conditioning systems and equipment into full operation and shall continue the operation of same during each working day of testing and balancing.

1.10 COORDINATION

A. Notice: Provide ten working days' advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air distribution systems have been satisfactorily completed.

1.11 HVAC CONTRACTOR RESPONSIBILITIES

A. Prepare each system for testing and balancing

B. Cooperate with the testing agencies, provide access to all work, equipment and systems.

C. Put all heating, ventilating and air conditioning systems and equipment into full operation and shall continue the operation of same during each working day of testing and balancing. Operate systems and under conditions required for proper testing, adjusting, and balancing.

D. Notify Testing Agency’s project manager, Owner and Engineer seven days prior to time system will be ready for testing, adjusting, and balancing. Project readiness shall include:

1. Systems are started and running (fans have been checked for proper rotation).

2. Permanent electrical power wiring is complete.

3. Verification that all ductwork is fabricated and installed as specified.

4. Ceilings are installed in critical areas where air pattern adjustment may be required. Access to balancing devices are provided.

5. All equipment and ductwork access doors are securely closed.

6. All balancing dampers are installed and in full open positions.

7. Rotating equipment (fans, etc.) have been statically and dynamically balanced at the factory. HVAC Contractor shall verify that equipment 10 Horsepower and greater has not become un-balanced either during shipping or installation of the equipment. HVAC Contractor shall report equipment found un-balanced to the Architect/Engineer/Owner and rebalance equipment prior to commence of the Testing, Adjusting and Balancing Work.

8. The HVAC Contractor shall coordinate the leakage testing of ductwork with the Testing and Balancing Contractor, to ensure that the duct testing is done in a timely manner so as not to interfere with the progress of the work

9. All ductwork etc. That is found is found to exceed the permissible leakage rates shall be immediately repaired by the HVAC Contractor, at no additional cost and in a timely manner so as not to interfere with the progress of the work.

10. System installation is complete, with Controls and Instrumentation installed and fully operational.

1.12 SEQUENCING AND SCHEDULING

A. Sequencing work to commence after completion of systems and schedule completion of work before Substantial Completion of Project.

1.13 DRAWING AND CONSTRUCTION REVIEW

A. Perform a preconstruction review of the following documents:

1. Updated construction drawings

2. Contract specifications

3. Addenda

4. Submittal data

5. Shop drawings

6. Automatic Control drawings

B. Prepare a report of the preconstruction review list of recommended changes to allow most effective balancing.

C. Perform four construction reviews of the mechanical installation during the progress of the project. Purpose of the reviews to be:

1. Identify potential problems for performing balancing.

2. Identify modifications which will aid balancing.

3. Schedule and coordinate balancing with other work and other trades.

D. Prepare a report of each construction review.

E. Pre-Balancing Conference: Prior to beginning of the testing, adjusting, and balancing procedures, schedule and conduct a conference with the Architect/Engineer and representatives of installers of the mechanical systems. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting, and balancing.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

A. HVAC Contractor shall, at the time of his bid, shall submit the name of the Testing and Balancing Contractors (TBC).

3.2 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Section 23 31 13 "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units and verify that they are accessible and their controls are connected and functioning.

K. Examine operating safety interlocks and controls on HVAC equipment.

L. Equipment is operable and in safe and normal condition.

M. Temperature control systems are installed complete and operable.

N. Proper thermal overload protection is in place for electrical equipment.

O. Pre and final filters are clean and in place.

P. Duct systems are clean of debris.

Q. Correct fan rotation.

R. All volume dampers are in place and are in the full open position.

S. Access doors are installed and closed and duct end caps are in place.

T. Terminal devices and air outlets are installed, connected and accessible and adjusted for full maximum flow.

U. Duct system leakage has been minimized. All duct systems requiring Leakage Tests have been tested and accepted.

V. Promptly report abnormal conditions in mechanical systems or conditions which prevent system balance.

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

X. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

Y. Commence of the Testing, Adjusting and Balancing work means that the Testing and Balancing Contractor has reviewed and accepts that the HVAC System as installed.

3.3 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:

1. Permanent electrical-power wiring is complete.

2. Automatic temperature-control systems are operational.

3. Equipment and duct access doors are securely closed.

4. Balance dampers are open.

5. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.

6. Windows and doors can be closed so indicated conditions for system operations can be met.

C. Prior to commence of Testing, Adjusting and Balancing Work, Testing and Balancing Contractor shall inspect all rotating equipment (fans, etc.) to verify that equipment is statically and dynamically balanced. If equipment is found to be un-balanced, Contractor shall report deficient equipment to Architect/Engineer/Owner. Testing, Adjusting and Balancing work shall not proceed on system until deficient equipment is correct.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" ASHRAE 111, NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section. The Testing and Balancing Contractor shall submit, along with his bid proposal for the Testing and Balancing work, the procedure for testing and balancing that he proposes to use.

1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts, or if required:

2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 23 33 00 "Air Duct Accessories."

3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 23 07 13 "Duct Insulation" and Section 23 07 19 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

D. Check airflow patterns from the outdoor-air intakes and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of air-handling-unit components.

K. Verify that air duct system is sealed as specified in Section 23 31 13 "Metal Ducts."

3.6 PROCEDURES FOR AIR HANDLING SYSTEMS

A. Air Distribution Systems: Operate the air handling systems and make adjustments in the controls and equipment as required to balance the systems to deliver the required design air quantities and temperatures.

1. Air Handling Systems:

a. First set of air filters shall be in place whenever fans are run. Replace with clean set of specified filters before testing.

b. Run supply fan with all dampers in their normal position (minimum outside air). Duplicate normal conditions as far as possible with clean filters in place, coils in operation, etc. Adjust for proper ratio of outside and return air.

2. NC (Noise Criteria) Tests: Operate the air handling systems after balancing, to determine that the schedule NC ratings in the spaces are not exceeded.

B. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:

a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
b. Measure static pressure directly at the fan outlet or through the flexible connection.
c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as heat-recovery equipment, and air filters, under final balanced conditions.

5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, and any other operating mode to determine the maximum required brake horsepower.

6. Test and adjust fan RPM to design requirements.

7. Test and record motor load in amperages at various filter percentages.

8. Test and adjust systems for design return air flow.

9. Test and record system static pressures suction and discharge.

10. Test and adjust systems for design outside air.

11. Test and record entering air temperatures (DB & WB). (Mixed air, preheat coils, cooling coil, heating coil).

12. Test and record leaving air temperatures (DB & WB). (Preheat coil, cooling coil, heating coil).

C. Room air terminal devices.

1. Adjust volume dampers for main duct, submain ducts, and branch ducts to indicated airflows within specified tolerances.

a. Measure airflow of mains, submain and branch ducts.

(i) Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

b. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.

c. Remeasure each main, submain and branch duct after all have been adjusted. Continue to adjust main, submain and branch ducts to indicated airflows within specified tolerances.

2. Measure air outlets and inlets without making adjustments.

a. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

3. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

4. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.

5. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.7 OUTDOOR AIR SUPPLY SYSTEMS:

A. Note: Outdoor air supply systems must be balanced with General Exhaust and Toilet Exhaust systems operating at their design levels.

B. Test and adjust fan RPM to design requirements.

C. Verify correct fan rotation.

D. Test and record motor load in amps in various flow rate percentages.

E. Make pitot tube traverses of main supply ducts to determine fan delivery. Measure design flow at 50% dirty filter condition (simulate).

F. Measure the static pressure profile of the air handling unit and system duct static pressure at selected points (minimum of 10) throughout the system, including points along the vertical riser shafts.

G. After adjustments to dampers throughout the system have been made, re-check fan performance adjusting as necessary.

H. Mark all damper settings.

I. For systems with terminal boxes, follow procedure outlined in previous sub-paragraph for balancing terminal boxes in air handling systems.

3.8 PROCEDURE FOR FAN SYSTEMS (EXHAUST)

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

B. Measure total airflow.

1. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:

a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
b. Measure static pressure directly at the fan outlet or through the flexible connection.
c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

4. Test and adjust fan RPM to design requirements

5. Test and record motor amperage for each phase leg

6. Verify fan rotation

C. Room air terminal devices

1. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

2. Measure airflow of main, submain and branch ducts.

   a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

3. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

4. Remeasure each main, submain and branch duct after all have been adjusted. Continue to adjust main, submain and branch ducts to indicated airflows within specified tolerances.

5. Measure air outlets and inlets without making adjustments.

   a. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

6. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

7. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.

8. Adjust patterns of adjustable outlets for proper distribution without drafts.

9. Corresponding supply air systems shall be operating at their design levels during the testing and balancing of return and exhaust systems.

10. Mark all damper settings.

3.9 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.

2. Motor horsepower rating.

3. Motor rpm.

4. Efficiency rating.

5. Nameplate and measured voltage, each phase.

6. Nameplate and measured amperage, each phase.

7. Starter thermal-protection-element rating.

B. Motors Driven by ECM control: Test for proper operation at speeds varying from minimum to maximum. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.10 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.11 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.

2. Airflow.

3. Entering- and leaving-air temperature at full load.

4. Voltage and amperage input of each phase at full load and at each incremental stage.

5. Calculated kilowatt at full load.

6. Fuse or circuit-breaker rating for overload protection.

B. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.

2. Wet-bulb temperature of entering and leaving air.

3. Airflow.

4. Air pressure drop.

3.12 Refrigerant suction pressure and temperature.TOLERANCES

A. Set HVAC system's air flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 5 percent.

2. Air Outlets and Inlets: Plus or minus 5 percent Where Multiple air outlets serve a single space, tolerance for total shall be plus 5 minus 10 percent.

3.13 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

3.14 INDOOR AIR QUALITY TESTING

A. Equipment Specification:

1. An infrared photo acoustic analyzer shall be used to monitor for carbon dioxide, carbon monoxide, and total volatile organic compounds levels. It is a real time analyzer equipment. The sampling installation in the building shall extend into the outside air, supply air and return air of each central HVAC system. In tenant areas the sampling points shall be as close as possible to the occupants breathing zones.

2. Calibration shall be performed in accordance with manufacturer specifications and recommended procedures.

B. Application (Analytical Methodology)

1. The analytical method used shall be a direct reading of the infrared spectroscopy technique, which classifies different organic compounds by their ability to absorb energy of specific wavelengths in the infrared region, specifically, center wavelength 3.4 μm and 3.6 μm respectively, as well as determine carbon dioxide and carbon monoxide in parts per million (ppm). The sub detection levels of the instrument, in parts per million (ppm) and milligrams per cubic meter (mg/m3), shall be as follows:

   a. Carbon dioxide ≈ 1.7 ppm;
   b. Carbon monoxide ≈ 0.2 ppm;
   c. Total volatile organic compounds, center wavelength 3.4 μm = 0.036 mg/m3. The instrument is calibrated for propane at this wavelength. The detection level of this filter is sensitive to changes in relative humidity.
   d. Total volatile organic compounds center wavelength 3.6 μm = 0.07 mg/m3. The instrument is calibrated for formaldehyde at this wavelength.

C. Indoor Air Quality Periodic Testing - Tenant Space

1. Two different sampling strategies shall be used, time specific sampling and 24 hour Continuous Monitoring.

2. The first strategy shall be the collection of indoor gaseous air quality data from a floor at a specific point in time (known as Time Specific Sampling), providing a snapshot of ambient conditions which are to be compared to applicable indoor air quality standards for verification of compliance with operating parameters.

3. The second strategy (known as 24-Hour Continuous Monitoring) expands upon the first through the use of additional equipment and provides a 24-hour study of conditions on the floor. The enhanced data produced by this configuration provides a more comprehensive view of ambient conditions and can record transient conditions that occur any time during monitoring. A graphical representation of gas concentrations over the sampling period is provided as part of the report.

D. Time-Specific Sampling

1. Indoor Gaseous Air Quality Monitoring for carbon dioxide (CO2), carbon monoxide (CO) and two classes of total volatile compounds (TVOC) utilizing air sampling and the Infra-red Photo acoustic Multi-Gas Analyzer shall be performed at 4 locations on each floor or every 10,000 feet, whichever is smaller as well as at the central HVAC equipment. This survey shall also include a visual inspection of the MER for parameters adversely affecting indoor air quality. The inspection should be focused on mechanical hygiene and should follow the parameters dictated by EPA's guidelines such as the "Building Air Quality: A Guideline For Building Owners and Facilities Managers".

2. 24-Hour Continuous Monitoring

a. Continual monitoring of Gaseous Indoor Air Quality Parameters shall include: carbon dioxide (CO2), carbon monoxide (CO) and two classes of total volatile organic compounds (TVOC). This monitoring shall be performed utilizing air sampling installations and Infra-red Photo-acoustic Multi-Gas Analyzer configured for continuous, unattended operation for a 24-hour period. This survey shall include a visual inspection of the MER for parameters adversely affecting indoor quality. The inspection should be focused on mechanical hygiene and should follow the parameters dictated by EPA's guidelines such as the "Building Air Quality' A Guideline For Building Owners and Facilities Managers".

3.15 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.

2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Fan curves.

2. Manufacturers' test data.

3. Field test reports prepared by system and equipment installers.

4. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.

2. Name and address of the TAB contractor.

3. Project name.

4. Project location.

5. Architect's name and address.

6. Engineer's name and address.

7. Contractor's name and address.

8. Report date.

9. Signature of TAB supervisor who certifies the report.

10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.

11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.

13. Data for terminal units, including manufacturer's name, type, size, and fittings.

14. Notes to explain why certain final data in the body of reports vary from indicated values.

15. Test conditions for fans performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters (at balanced condition).
    c. Cooling coil, wet- and dry-bulb conditions. coil condition (wet or dry)
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems. (Maximum and minimum).
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

i. ECM setting (maximum & minimum)

D. System Diagrams: Include schematic layouts of air distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.

2. Duct, outlet, and inlet sizes.

3. Terminal units.

4. Balancing stations.

5. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches (mm), and bore.
i. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches (mm), and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).

3. Test Data (Design and Actual Values):

a. Total air flow rate in cfm (L/s).
b. Total system static pressure in inches wg (Pa).
c. Fan rpm.
d. Discharge static pressure in inches wg (Pa). (External)
e. Fan suction static pressure inches wg (Pa)
f. If fan discharges into a plenum, discharge static pressure in plenum inches wg (Pa).
g. Filter static-pressure differential in inches wg (Pa).

h. Preheat-coil static-pressure differential in inches wg (Pa).
i. Cooling-coil static-pressure differential in inches wg (Pa).
j. Heating-coil static-pressure differential in inches wg (Pa).
k. Outdoor airflow in cfm (L/s).
l. Return airflow in cfm (L/s).
m. Outdoor-air damper position.
n. Return-air damper position.
o. ECM setting (maximum & minimum)
p. For systems with air flow stations, verify air flow readings vs balance condition at maximum and minimum
q. Fan discharge wet and dry-bulb temperatures in deg F (deg C).
r. Input voltage at each connection
s. Operating amperage at balanced condition for each phase leg

F. Apparatus-Coil Test Reports:

1. Coil Data: (Preheat, Cooling, Heating)

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch (mm) o.c.
f. Make and model number.
g. Face area in sq. ft. (sq. m).
h. Tube size in NPS (DN).
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Design and Actual Values):

a. Air flow rate in cfm (L/s).
b. Average face velocity in fpm (m/s).
c. Air pressure drop in inches wg (Pa).
d. Outdoor-air, wet- and dry-bulb temperatures in deg F (deg C).
e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
f. Mixed air, wet and dry-bulb temperatures in deg F (deg C).
g. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
h. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
i.
j. Entering-water temperature in deg F (deg C).
k. Leaving-water temperature in deg F (deg C).
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig (kPa).
n. Refrigerant suction temperature in deg F (deg C).

G. Electric-Coil Test Reports: For electric coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Coil identification.
d. Capacity in Btu/h (kW).
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Air flow rate in cfm (L/s).
i. Face area in sq. ft. (sq. m).
j. Minimum face velocity in fpm (m/s).

2. Test Data (Indicated and Actual Values):

a. Heat output in Btu/h (kW).
b. Air flow rate in cfm (L/s).
c. Air velocity in fpm (m/s).
d. Entering-air temperature in deg F (deg C).
e. Leaving-air temperature in deg F (deg C).
f. Voltage at each connection.
g. Amperage for each phase.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.
b. Location.
c. Manufacturer and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Fan arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches (mm), and bore.
i. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches (mm), and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm (L/s).
b. Total system static pressure in inches wg (Pa).

c. Fan rpm.
d. Discharge static pressure in inches wg (Pa).
e. Suction static pressure in inches wg (Pa).
f. Variable frequency drive setting (maximum & minimum)
g. For systems with air flow stations, verify air flow readings vs balance condition at maximum and minimum
h. Input voltage at each connection
i. Operating amperage at balanced condition for each phase leg

I. Round and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F (deg C).
d. Duct static pressure in inches wg (Pa).
e. Duct size in inches (mm).
f. Duct area in sq. ft. (sq. m).
g. Indicated air flow rate in cfm (L/s).
h. Indicated velocity in fpm (m/s).
i. Actual air flow rate in cfm (L/s).
j. Actual average velocity in fpm (m/s).
k. Barometric pressure in psig (Pa).

J. Fan Coil (AC unit) (Constant VolumeReports

1. Unit Data

a. Air handling unit designation
b. Location
c. Terminal Box type (constant, variable, fan, etc.)
d. Model number and terminal box size
e. Terminal box inlet size in inches (mm)
f. Motor type (fan powered only)

2. Test Data (Design and Actual Values) (Supply, Return & Exhaust)

a. Terminal box inlet static pressure in inches (Pa)
b. Primary air flow at inlet cfm (L/s) (maximum & minimum)
c. Supply air flow at discharge cfm (L/s) (maximum & minimum)
d. Primary air flow temperature in deg F (deg C)
e. Supply air flow temperature (heating mode) in deg F (deg C)
f. Supply air flow temperature (cooling mode) (fan powered only) in deg F (deg C)

K. Room Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Room served.
e. Manufacturer.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft. (sq. m) and area factor.

2. Test Data (Indicated and Actual Values):

a. Air flow rate in cfm (L/s).
b. Air velocity in fpm (m/s).
c. Preliminary air flow rate as needed in cfm (L/s).
d. Preliminary velocity as needed in fpm (m/s).
e. Final air flow rate in cfm (L/s).
f. Final velocity in fpm (m/s).
g. Space temperature in deg F (deg C).

L. System-Coil Reports: For heat coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil size in inches (mm)
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):
a. Entering-air temperature in deg F (deg C).
b. Leaving-air temperature in deg F (deg C).
c. Entering air temperature in deg F (deg C)
d. Leaving air temperature in deg F (deg C)
e. Space temperature in deg F (deg C)

M. Incremental Unit Reports (Fan Coil Units, etc.) Reports

1. Unit Data

a. Unit identification
b. Locations
c. Room or Area Served
d. Manufacturer
e. Model number

2. Test Data (Design and Actual Valves)

    a. Air flow rate in cfm (L/s) (ducted units only)
    b. Entering air temperature in deg F (deg C)
    c. Leaving air temperature in deg F (deg C)
    d. Space temperature in deg F (deg C)
    e. Flowmeter type

N. Instrument Calibration Reports:

1. Report Data:

    a. Instrument type and make.
    b. Serial number.
    c. Application.
    d. Dates of use.
    e. Dates of calibration.

3.16 VERIFICATION OF CONTROL OPERATION

A. General: Perform the checks outlined in the following for all air system controls:

1. Thermostats and humidistats - Verify calibration and operation of all thermostats and humidistats. Any Deficiencies shall be reported for correction. Recheck after correction. Record thermostat set point and output signal, space temperature.

2. Damper Operation - Verify operation and position for all dampers. Any Deficiencies shall be reported for correction. Recheck after correction.

3. Other Controls - Simulate control operations with control contractor in accordance with design requirements and manufacturer's recommendations. Any deficiencies shall be reported for correction. Recheck after correction.

3.17 DUCT LEAKAGE TESTS (IF NOT DONE BY HVAC CONTRACTOR.)

A. Testing and Balancing Contractor shall provide duct leakage tests on the system as specified below. See Section 23 13 16 titled "Metal Ducts" Part 3 sub-paragraph titled "Duct Schedule" for duct leakage requirements

B. Testing and Balancing Contractor shall meet with HVAC Contractor and coordinate the schedule for duct leakage testing. Testing and Balancing Contractor shall outline to the HVAC Contractor the assistance, equipment, duct openings etc. he will require from the HVAC Contractor in order to complete the leakage tests.

C. Leakage Tests

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.

2. Test the following systems:

   a. All ducts (supply, return, exhaust etc.) Pressure Class +/- 2" W G. or less before insulation is applied shall be pressure tested at scheduled external static pressure and joints for all mains, risers and branches shall be check for leakage and repair if necessary. Noisy and whistling leaks shall be repaired and the system shall then be retested
   b. Supply Ducts with a Pressure Class Higher Than 2-Inch wg (500 Pa): Test representative duct sections, selected by Architect from sections installed, totaling no less than 100 percent of total installed duct area for each designated pressure class.
   c. Return Ducts with a Pressure Class Higher Than 2-Inch wg (500 Pa): Test representative duct sections, selected by Architect from sections installed, totaling no less than 100 percent of total installed duct area for each designated pressure class.
   d. Exhaust Ducts with a Pressure Class Higher Than 2-Inch wg (500 Pa): Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
   e. Outdoor Air Ducts with a Pressure Class Higher Than 2-Inch wg (500 Pa): Test representative duct sections, totaling no less than 100 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

4. Test for leaks before applying external insulation.

5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.

6. Give ten days' advance notice for testing.

3.18 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.

2. Check the following for each system:

   a. Measure airflow of at least 15 percent of air outlets.
   b. Measure water flow of at least 10 percent of terminals.
   c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
   d. Verify that balancing devices are marked with final balance position.
   e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Commissioning Authority.

2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Commissioning Authority.

3. Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.

2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.19 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 23 05 93

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SECTION 23 07 13 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
7. Outdoor, concealed supply and return.
8. Outdoor, exposed supply and return.
9. Outdoor exposed exhaust ductwork

B. Related Sections:

1. Section 230716 "HVAC Equipment Insulation."
2. Section 230719 "HVAC Piping Insulation."
3. Section 233113 "Metal Ducts" for duct liners.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. LEED Submittals:
1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical.
2. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Environmental Chambers.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.

2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.

3. Detail application of field-applied jackets.

4. Detail application at linkages of control devices.

D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Sheet Form Insulation Materials: 12-inches (300 mm) square.

2. Sheet Jacket Materials: 12-inches (300 mm) square.

3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 23, Section Titled "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule article for where insulating materials shall be applied.

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

C. 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.

D. 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.

F. Roof ducts require polyisocyanurate board with white EPDM jacket cover fully adhered.

G. Mineral-Fiber Blanket Insulation (Faced) (Type D-1):

1. Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type II with factory-applied FSK jacket

2. Insulation Characteristics

   a. Thermal Conductivity (ASTM 518): 0.29 BTU*inch per Hr*FT2*°F (Labeled Thickness)

   b. Thermal Conductivity (ASTM 518): 0.27 BTU*inch per Hr*FT2*°F (Compressed Thickness)

   c. Compressed Thickness: 75% of Labeled Thickness

   d. Density: 0.75 Lbs per Ft3

   e. Maximum Flame Spread: 25

   f. Maximum Smoke Spread: 50

   g. Maximum Operating Temperature Index (Faced) (ASTM C411): 250°F

   h. Maximum Operating Temperature Index (Unfaced) (ASTM C411): 350°F

   i. Fungi Resistance (ASTM 1338): No promoting or breeding of fungi

3. Products: Subject to compliance with requirements, provide one of the following:

   a. CertainTeed Corp.; SoftTouch Duct Wrap.

   b. Johns Manville; Microlite.

   c. Knauf Insulation; Friendly Feel Duct Wrap.

   d. Manson Insulation Inc.; Alley Wrap.

   e. Owens Corning; SOFTR All-Service Duct Wrap.

H. Mineral-Fiber Board Insulation (Faced) (Type D-2)

1. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. Provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2. Insulation Characteristics

   a. Thermal Conductivity (ASTM 518): 0.22 BTU*inch per Hr*FT2*°F

   b. Density: 4.25 Lbs per Ft3

   c. Maximum Flame Spread: 25

   d. Maximum Smoke Spread: 50

e. Maximum Operating Temperature Index (Faced)

(i) Faced Side; 150°F

(ii) Unfaced Side; 450°F

f. Maximum Operating Temperature Index: 450°F

g. Fungi Resistance (ASTM 1338): No promoting or breeding of fungi

3. Products: Subject to compliance with requirements, provide one of the following:

a. Certain Teed Corp; Centrpro

b. Johns Manville; 800 spin-glas

c. Knauf Insulation; Insulation Board.

I. Mineral-Fiber Blanket Insulation (Unfaced) (Type D-3)

1. Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II.

2. Insulation Characteristics

a. Thermal Conductivity (ASTM 518): 0.29 BTU*inch per Hr*FT2*°F (Labeled Thickness)

b. Thermal Conductivity (ASTM 518): 0.27 BTU*inch per Hr*FT2*°F (Compressed Thickness)

c. Compressed Thickness: 75% of Labeled Thickness

d. Density: 0.75 Lbs per Ft3

e. Maximum Flame Spread: 25

f. Maximum Smoke Spread: 50

g. Maximum Operating Temperature Index (Unfaced) (ASTM C411): 350°F

h. Fungi Resistance (ASTM 1338): No promoting or breeding of fungi.

3. Products: Subject to compliance with requirements, provide one of the following:

a. CertainTeed Corp.; SoftTouch Duct Wrap.

b. Johns Manville; Microlite.

c. Knauf Insulation; Friendly Free Duct Wrap

d. Manson Insulation Inc.; Alley Wrap.

e. Owens Corning; SOFTR All-Service Duct Wrap.

4. Exposed Ducts: Provide a factory-applied vinyl jacket on ducts. For exposed ducts in public areas, cover staples or speed clips with a pressure sensitive tape compatible with jacket to ensure neat appearance

J. Mineral-Fiber Board Insulation (Unfaced) (Type D-4)

1. Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB.

2. Insulation Characteristics

a. Thermal Conductivity (ASTM 518): 0.22 BTU*inch per Hr*FT2*°F

b. Density: 4.25 Lbs per Ft3

c. Maximum Flame Spread: 25

d. Maximum Smoke Spread: 50

e. Maximum Operating Temperature Index 450°F

f. Fungi Resistance (ASTM 1338): No promoting or breeding of fungi

3. Products: Subject to compliance with requirements, provide one of the following:

a. Certain Teed Corp; CentraPro

b. Johns Manville; 800 Spin-glas.

c. Knauf Insulation; Insulation Board

K. Mineral-Fiber, Pipe and Tank Insulation (Type D-5)

1. Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ or FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2. Products: Subject to compliance with requirements, provide one of the following:

a. CertainTeed Corp.; CrimpWrap.

b. Johns Manville; MicroFlex.

c. Knauf Insulation; Pipe and Tank Insulation.

d. Manson Insulation Inc.; AK Flex.

e. Owens Corning; Fiberglas Pipe and Tank Insulation.

L. Flexible Elastomeric Insulation (Type D-7):

1. Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.

2. Insulation Characteristics

a. Thermal Conductivity; 0.245 Btu*inch per Hr*Sq Ft*°F per ASTM C177/C518

b. Surface Burning Characteristics (Maximum Insulation Thickness 2 Inches) per ASTM E84

(i) Flame Spread; 25 Maximum

(ii) Smoke Developed; 50 Maximum

c. Surface Temperature (Continuous); -297°F to 300°F per ASTM C411

d. Water Vapor Permeability; 0.03 Perm per ASTM E96

e. Fungi/Resistance; No Growth per ASTM C1338/ UL 181

3. Products: Subject to compliance with requirements, provide one of the following:

a. Aeroflex USA, Inc.; Aerocel.

b. Armacell LLC; AP Armaflex.

c. K-Flex USA; Insul-Sheet, K-Flex Gray Duct Liner, and K-FLEX LS

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Aeroflex USA, Inc.; Aeroseal.

b. Armacell LLC; Armaflex 520 Adhesive.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.K-Flex USA; R-373 Contact Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.Eagle Bridges - Marathon Industries; 225.

b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, provide one of the following

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.

b. Eagle Bridges - Marathon Industries; 225.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Foster Brand, Specialty Construction Brands, Inc., (30-80/30-90).

b. Vimasco Corporation; (749).

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).

4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.

5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., (Encacel).

b. Eagle Bridges - Marathon Industries; (570).

c. Foster Brand, Specialty Construction Brands, Inc., (60-95/60-96).

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.

3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).

4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.

5. Color: White.

2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands (CP-50AHV2)

b. Foster Brand, Specialty Construction Brands (30-36)

c. Vimasco Corp. (713 &714)

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.

4. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).

5. Color: White.

2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., (CP-76).

b. Foster Brand, Specialty Construction Brands, Inc., (95-44).

c. Mon-Eco Industries, Inc.; (44-05)

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, elastomeric sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).

5. Color: Aluminum.

6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. ASJ Flashing Sealants, and Vinyl Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, elastomeric sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).

5. Color: White.

6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.

5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. in. (2 strands by 2 strands/sq. mm) for covering ducts.

1. Products: Subject to compliance with requirements, provide the following:

a. Childers Brand, Specialty Construction Brands, Inc., (Chil-Glas No. 5).

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for ducts.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; (Mast-A-Fab).

b. Vimasco Corporation; Elastafab (894).

2.8 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).

1. Products: Subject to compliance with requirements, provide the following:

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.9 FIELD-APPLIED JACKETS

A. Metal Jacket:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc.; (Metal Jacketing Systems).

b. ITW Insulation Systems; (Aluminum and Stainless Steel Jacketing).

c. RPR Products, Inc.; (Insul-Mate).

2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Sheet and roll stock ready for shop or field sizing.

b. Finish and thickness are indicated in field-applied jacket schedules.

c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, polysurlyn heat laminated to aluminum jacket

d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, polysurlyn heat laminated to aluminum jacket

e. Install per manufacturer’s recommendations

f. For outdoor installations, all longitudinal and circumferential joints shall be made water tight

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

a. Sheet and roll stock ready for shop or field sizing Factory cut and rolled to size.

b. Material, finish, and thickness are indicated in field-applied jacket schedules.

c. Moisture Barrier for Indoor Applications 3-mil- (0.075-mm-) thick, polysurlyn heat laminated to aluminum jacket.

d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, polysurlyn heat laminated to aluminum jacket.

e. Install per manufacturer's recommendations

f. For outdoor installations, all longitudinal and circumferential joints shall be made water tight

2.10 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one of the following:

a. ABI, Ideal Tape Division; (428 AWF ASJ).

b. Avery Dennison Corporation, (Fasson 0836).

c. Compac Corporation; (104 and 105).

2. Width: 3 inches.

3. Thickness: 10.8 mils.

4. Adhesion: 45 ounces inch in width.

5. Elongation: 2 percent.

6. Tensile Strength: 55 lbf/inch in width.

7. Service temperature -40°F to 300°F.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one of the following:

a. ABI, Ideal Tape Division; 491 AWF FSK.

b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.

c. Compac Corporation; 110 and 111.

d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches

3. Thickness: 9.0 mils

4. Adhesion: 45 ounces inch in width.

5. Elongation: 2 percent.

6. Tensile Strength: 40 lbf/inch in width.

7. Service temperature -40°F to 250°F.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide one of the following:

a. ABI, Ideal Tape Division; (488 AWF).

b. Avery Dennison Corporation, Specialty Tapes Division; (Fasson 0800).

c. Compac Corporation; (120).

d. Venture Tape; (3520 CW).

2. Width: 2 inches.

3. Thickness: 3.6 mils.

4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.

5. Elongation: 4 percent.

6. Tensile Strength: 21 lbf/inch in width.

2.11 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. ITW Insulation Systems; Gerrard Strapping and Seals.

b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.

3. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.

4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated.

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

        (i) AGM Industries, Inc.; CWP-1.

        (ii) GEMCO; CD.

        (iii) Midwest Fasteners, Inc.; CD.

        (iv) Nelson Stud Welding; TPA, TPC, and TPS.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

        (i) AGM Industries, Inc.; CHP-1.

        (ii) GEMCO; Cupped Head Weld Pin.

        (iii) Midwest Fasteners, Inc.; Cupped Head.

        (iv) Nelson Stud Welding; CHP.

3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel, aluminum or stainless-steel compatible with pine material sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

    a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

        (i) AGM Industries, Inc.; RC-150.

        (ii) GEMCO; R-150.

        (iii) Midwest Fasteners, Inc.; WA-150.

        (iv) Nelson Stud Welding; Speed Clips.

    b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Staples: Outward-clinching insulation staples, nominal ½ or 3/4-inch- wide, stainless steel or Monel.

D. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel or 16 gauge copper clad pine.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. C & F Wire.

2.12 CORNER ANGLES

A. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.

B. Stainless-Steel Corner Angles: 0.024 inch (0.61 mm) thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316.

2.13 WEATHERPROOFING FINISHES FOR OUTDOOR DUCTWORK (SUPPLY, RETURN & EXHAUST

A. Outdoor Rectangular Duct Work and Irregular Surfaces:

1. Ductwork and irregular surfaces shall be insulated as specified in Part 3 of this section and provided with a weatherproof finish as described herein.

2. The surfaces shall be weather protected with two coats of Insulcoustic VI-AC Mastic, I-C 551, or Benjamin Foster GPM Mastic with open weave glass cloth membrane imbedded between the coats. The total thickness of the coating shall be a minimum of 1/8". Roof ducts require polyisocyanurate board with white EPDM jacket cover fully adhered.

B. Outdoor ductwork (supply, return and exhaust) that is not insulated shall be provided with a weatherproof finish as described in subparagraphs “A” above.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.

   a. Apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

5. Apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.

4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

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.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Before applying insulation to ducts or plenums, sheet metal duct shall be clean and dry.

2. Check all ducts and plenums to verify that all seams and joints of ducts are tightly sealed

3. For ducts and plenums with air supply temperatures above 70°F, install insulations as follows:

a. Apply adhesive to all surfaces of duct or plenum per recommendation of insulation manufacturer

b. For horizontal ducts over 24 inches in width, install on bottom of duct capacitor-discharge-weld pins, impale insulation over weld pin and install speed clips to hold insulation. Cut excess portion of pins above speed clips.

c. For vertical ducts, install on all four sides of duct capacitor-discharge-weld pins, impale insulation over weld pin and install speed clips to hold insulation. Cut excess portion of pins above speed clips.

d. For plenums, install on sides and bottom of plenum capacitor-discharge-weld pins, impale insulation over weld pin and install speed clips to hold insulation. Cut excess portion of pins above speed clips.

e. For exposed ducts and plenums, butt all joints

f. For concealed ducts, overlap all longitudinal and circumferential joints of insulation 2 inches.

g. For concealed ducts, secure insulation to ducts with 16 gauge copper clad wire 12 inches on center.

h. Exposed ducts shall be provided with a vinyl jacket. Secure insulation with 2" longitudinal lap and ½ or ¾ inch outward-clinching staples 6 inches on center. Butt circumferential joints. Tape circumferential ducts with tape compatible with jacket

i. Maximum compressibility 25% of scheduled thickness. Do not over compress insulation.

4. For ducts and plenums with air supply temperatures below 70°F, install insulations with a continuous vapor barrier as follows:

a. Note that insulation (with vapor barrier) shall be continuous across all duct joints, hot water reheat coil pipe bends (insulated end caps), diffusers, etc. so as to provide a continuous, fully insulated with uninterrupted vapor barrier from the fan discharge to the diffusers.

b. Apply adhesive to all surfaces of duct or plenum per recommendation of insulation manufacturer

c. For horizontal ducts over 24 inches in width, install on bottom of duct capacitor-discharge-weld pins, impale insulation over weld pin and install speed clips to hold insulation. Cut excess portion of pins above speed clips.

d. For vertical ducts, install on all four sides of duct capacitor-discharge-weld pins, impale insulation over weld pin and install speed clips to hold insulation. Cut excess portion of pins above speed clips. Cover exposed pins and washers with pressure-sensitive tape matching insulation facing.

e. For plenums, install on sides and bottom of plenum capacitor-discharge-weld pins, impale insulation over weld pin and install speed clips to hold insulation. Cut excess portion of pins above speed clips.

f. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Butt adjacent section of insulation at joints tightly and secure lap with ½ or ¾ inch outward clinching staples 6 inches on center. Install pressure sensitive tape matching insulation facing circumferential joints, longitudinal seams and protrusions.

g. Maximum compressibility 25% of scheduled thickness. Do not over compress insulation.

h. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct.

B. Board Insulation Installation on Ducts and Plenums:

1. Before applying insulation to ducts or plenums, sheet metal duct shall be clean and dry.

2. Check all ducts and plenums to verify that all seams and joints of ducts are tightly sealed

3. For ducts and plenums with air supply temperatures above 70°F, install insulations as follows:

a. Install capacitor-discharge-weld pins to top, bottom and both sides of horizontal ducts and all four sides of vertical duct.

b. For ducts smaller than 18 inches, install a minimum of two rows of weld pins, 16 inches on center and a maximum of 3 inches from insulation edge

c. Install additional as required to hold insulation tight to cross bracing.

d. Install impale insulation over weld pins, install speed washers and cut excess portion of pin above speed clip.

e. Fill longitudinal seams, circumferential joints and voids in insulation with a cement compatible insulation material.

f. Exposed ducts shall be provided with a vinyl jacket, create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Butt adjacent section of insulation at joints tightly and secure lap with ½ or ¾ inch outward clinching staples 6 inches on center

4. For ducts and plenums with air supply temperatures below 70°F, install insulations with a continuous vapor barrier as follows:

a. Note that insulation (with vapor barrier) shall be continuous across all duct joints, hot water reheat coil pipe bends (insulated end caps), diffusers, etc. so as to provide a continuous, fully insulated with uninterrupted vapor barrier from the fan discharge to the diffusers.

b. Install capacitor-discharge-weld pins to top, bottom and both sides of horizontal ducts and all four sides of vertical duct.

c. For ducts smaller than 18 inches, install a minimum of two rows of weld pins, 16 inches on center and a maximum of 3 inches from insulation edge

d. Install additional as required to hold insulation tight to cross bracing.

e. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment.

f. Butt adjacent section of insulation at joints tightly.

g. Install impale insulation over weld pins, install speed washers and cut excess portion of pin above speed clip.

h. Fill longitudinal seams, circumferential joints and voids in insulation with a cement compatible insulation material.

i. Secure lap with ½ or ¾ inch outward clinching staples 6 inches on center.

j. Install pressure sensitive tape matching insulation facing circumferential joints, longitudinal seams and protrusions.

k. Cover exposed pins and washers with pressure-sensitive tape matching insulation facing.

l. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.

2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.

3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.

2. Install lap or joint strips with same material as jacket.

3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.

5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

3.8 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.

2. Indoor, exposed supply and outdoor air.

3. Indoor, concealed return located in unconditioned space.

4. Indoor, exposed return located in unconditioned space.

5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.

6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

7. Outdoor, concealed supply and return.

8. Outdoor, exposed supply and return.

9. Outdoor exposed exhaust ductwork

B. Items Not Insulated:

1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.

2. Factory-insulated flexible ducts.

3. Factory-insulated plenums and casings.

4. Flexible connectors.

5. Vibration-control devices.

6. Factory-insulated access panels and doors.

3.9 DUCT AND PLENUM INSULATION SCHEDULE

A. Insulation Schedule Notes

1. Ducts and casing that are acoustically lined (lining specified in another Section of Division 23) do not required exterior insulation except where the duct is located outdoors. For acoustically lined ducts and casing located outdoors, the thickness of insulation shall be as scheduled for duct located outdoors.

2. Weatherprotect outdoor supply, return and exhaust air ducts as specified in a previous paragraph in Part 2 of this specification.

3. Weatherprotect vertical conditioned air supply, return and exhaust air risers as located in a weather tight Architectural Enclosure.

4. Ducts and casing that are acoustically lined (lining specified in another Section of Division 23) do not required exterior insulation. If the “R” value for the duct lining is less than the scheduled “R,” either increase the thickness of the lining or provide external insulation so that the total “R” (lining plus insulation is at least equal to scheduled “R”

B. Duct Insulation Schedule (Also refer to note on drawing M-100 for location of insulation and acoustical lining)

DUCT INSULATION SCHEDULE			
SYSTEM	INSULATION TYPE	INSULATION THICKNESS INCHES	REMARKS
Conditioned supply air (70°F or less) duct from fan discharge to device that reduces air pressure (concealed and exposed in mechanical rooms above 8 -0") (See Note 4)	Type D-1	2	Insulation "R" value (minimum) = 6 but not less than 2 inches
Conditioned supply air (70°F or less) duct from fan discharge to device that reduces air pressure (exposed in mechanical rooms below 8' -0") (See Note 4)	Type D-2	1 1/2	Insulation "R" value (minimum) = 6 but not less than 1 1/2 inches
Conditioned supply air duct (70°F or less) from fan discharge or device that reduces pressure to air distribution device including air distribution device plenums (See Note 4)	Type D-1	2	Insulation "R" value (minimum) = 6 but not less than 2 inches
Return Air Ducts (See Note 4)	Type D-1	1 1/2	Insulation "R" value (minimum) = 6 but not less than 1 1/2 inches. Return air ducts in ceiling plenums do not require insulation except return ducts directly below roof shall be insulated.

DUCT INSULATION SCHEDULE			
SYSTEM	INSULATION TYPE	INSULATION THICKNESS INCHES	REMARKS
Plenums (supply, return and exhaust)	Type D-2	1 1/2	Insulation "R" value (minimum) = 6 but not less than 1 1/2 inches
Low pressure supply air (70°F or greater) from fan discharge to air distribution devices including air distribution device plenum (See Note 4)	Type D-3 for all concealed ducts and exposed ducts in mechanical rooms above 8'-0"; Type D-4 for exposed ducts in mechanical room below 8'-0"	2 inch Type D-3; 1 1/2 inch Type D-4;	Insulation "R" value = 6 but not less than 2 inches Type D-3; 1 1/2 Type D-4. Exposed ducts shall be provided with a factory applied vinyl jacket
Low pressure supply air (70°F or less) from fan discharge to air distribution devices including air distribution device plenum (See Note 4)	Type D-1 for all concealed ducts and exposed ducts in mechanical rooms above 8'-0"; Type D-2 for exposed ducts in mechanical room below 8'-0"	2 inch Type D-1; 1 1/2 inch Type D-2;	Insulation "R" value (minimum) = 6 but not less than 2 inches Type D-1; 1 1/2 Type D-2.
Low pressure supply air (70°F or less) from device that reduces pressure to air distribution devices including air distribution device plenum	Type D-1	2	Insulation "R" value (minimum)e = 6 but not less than 2 inches

DUCT INSULATION SCHEDULE			
SYSTEM	INSULATION TYPE	INSULATION THICKNESS INCHES	REMARKS
Ducts and plenums containing all a percentage of outside air from plenum to inlet of air handling unit or fan	Type D-1 for all concealed ducts and exposed ducts in mechanical rooms above 8'-0"; Type D-2 for exposed ducts in mechanical room below 8'-0"	2 inch Type D-1; and Type D-2;	
Conditioned supply air (greater or less than 70°F) located outdoors from fan discharge to 3 feet below roof or inside wall; (See Note 1 & Note 2)	Type D-1	2 1/2	Insulation "R" value (minimum)= 8 but not less than 2 1/2 inches
Return air duct located outdoors from 3 feet below roof or inside wall to equipment; (See Note 1 & Note 2)	Type D-1	2 1/2	Insulation "R" value (minimum) = 8 but not less than 2 1/2 inches
Exhaust Ducts from Automatic Control Damper to exhaust plenum	Type D-2	2	
All outdoor exhaust ductwork from 3 feet below roof or inside wall to equipment	Type D-1	2	
All outdoor exhaust ductwork from 3 feet below roof or inside wall to Energy Recovery Unit	Type D-1	2 ½	

3.10 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Ducts and Plenums, Exposed.

1. Aluminum; Smooth surface 0.32 inch (0.81 mm) thick for round ducts or pipes 24 inches and diameter and smaller; 0.40 inch (1.0 mm) thick for round ducts and pipes 25 inches and larger

2. Painted Aluminum; Smooth surface 0.32 inch (0.81 mm) thick for round ducts or pipes 24 inches and diameter and smaller; 0.40 inch (1.0 mm) thick for round ducts and pipes 25 inches and larger

3. Stainless Steel; Type 304, smooth 2B finish surface 0.20 inch (0.51 mm) thick for round ducts or pipes 24 inches and diameter and smaller; 0.24 inch (0.51mm) thick for round ducts and pipes 25 inches and larger.

END OF SECTION 23 07 13

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SECTION 23 07 19 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Condensate drain piping.

2. Refrigerant suction and hot-gas piping, indoors and outdoors.

B. Related Sections:

1. Division 23 Section "HVAC Equipment Insulation."

2. Division 23 Section "Duct Insulation."

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

B. LEED Submittals:

1. Product Data for Credit EQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.

2. Laboratory Test Reports for Credit EQ 4: For adhesives and sealants, documentation indicating that product complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.

2. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.

3. Detail removable insulation at piping specialties.

4. Detail application of field-applied jackets.

5. Detail application at linkages of control devices.

D. Qualification Data: For qualified Installer.

E. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule.

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

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

D. Mineral-Fiber, Preformed Pipe Insulation: (TYPE P-1)

1. Products: Subject to compliance with requirements. Provide one of the following:

a. Fibrex Insulations Inc.; Coreplus 1200.
b. Johns Manville; Micro-Lok.
c. Knauf Insulation; 1000-Degree Pipe Insulation.
d. Manson Insulation Inc.; Alley-K.
e. Owens Corning; Fiberglas Pipe Insulation.

2. Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" paragraph.

3. Insulation Characteristics

a. Thermal Conductivity; 0.23 Btu*inch per Hr*Sq Ft*°F @ 75°F
b. Operating Temperature Range; 0°F to 850°F
c. Surface Burning Characteristics (ASTM E84, UL-723, NFPA 255
1) Maximum Flame Spread: 25
2) Maximum Smoke Spread: 50
d. Shrinkage (per ASTM C 356); None
e. Fungi and Bacteria Resistance; No promoting or breeding of fungi or bacteria

4. Insulation to be provided with a longitudinal self-sealing lap (SSL). Self sealing lap (SSL) adhesive closure shall provide a positive mechanical and vapor longitudinal seam.

5. Circumferential joints shall be sealed with self-sealing butt strip. Self sealing lap (SSL) adhesive closure shall provide a positive mechanical and vapor circumferential joint.

E. Flexible Elastomeric Insulation (Type P-3)

1. Products: Subject to compliance with requirements, provide one of the following:

a. Aeroflex USA, Inc.; Aerocel.
b. Armacell LLC; AP Armaflex.
c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

2. Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

3. Insulation Characteristics

a. Thermal Conductivity; 0.257 Btu*inch per Hr*Sq Ft*°F @ 75°F per ASTM C-177
b. Service Temperature Range; -295°F to 300°F per ASTM C-411
c. Water Vapor Permeability; 0.10 perm per ASTM C-355
d. Moisture Absorption (weight %); 0.2 % per ASTM C 209
e. Surface Burning Characteristics (ASTM E84)(for pipe sizes 2 inch and less
1) Maximum Flame Spread: 25
2) Maximum Smoke Spread: 50
f. Density; 4/6 Lbs/ Ft3 per ASTM D1667

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Ramco Insulation, Inc.; Super-Stik.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Ramco Insulation, Inc.; Thermokote V.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

1. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F (minus 73 to plus 93 deg C).

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

C. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Aeroflex USA, Inc.; Aeroseal.
   b. Armacell LLC; Armaflex 520 Adhesive.
   c. Foster Brand, Specialty Construction Brands, Inc., 85-75.
   d. K-Flex USA; R-373 Contact Adhesive.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Childers Brand, Specialty Construction Brands, Inc., CP-127.
   b. Eagle Bridges - Marathon Industries; 225.
   c. Foster Brand, Specialty Construction Brands, Inc., 85-60/85-70.

d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

E. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., CP-82.
b. Eagle Bridges - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., 85-50.
d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Foster Brand, Specialty Construction Brands, Inc., 30-80/30-90.
b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).

4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.

5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., Encacel.
b. Eagle Bridges - Marathon Industries; 570.
c. Foster Brand, Specialty Construction Brands, Inc., 60-95/60-96.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.

3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).

4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.

5. Color: White.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., CP-10.
b. Eagle Bridges - Marathon Industries; 550.
c. Foster Brand, Specialty Construction Brands, Inc., 46-50.
d. Mon-Eco Industries, Inc.; 55-50.
e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).

4. Solids Content: 60 percent by volume and 66 percent by weight.

5. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Childers Brand, Specialty Construction Brands, Inc., CP-50 AHV2.
   b. Foster Brand, Specialty Construction Brands, Inc., 30-36.
   c. Vimasco Corporation; 713 and 714.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.

4. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).

5. Color: White.

2.6 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   b. Eagle Bridges - Marathon Industries; 405.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Pittsburgh Corning Corporation; Pittseal 444.

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Permanently flexible, elastomeric sealant.

4. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).

5. Color: White or gray.

6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

7. Use sealants that comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
    b. Eagle Bridges - Marathon Industries; 405.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
    d. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).

5. Color: Aluminum.

6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

7. Use sealants that comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

C. ASJ Flashing Sealants, and Vinyl Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, elastomeric sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).

5. Color: White.

6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

7. Use sealants that comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

4. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perms) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas Number 10.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for pipe.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
b. Vimasco Corporation; Elastafab 894.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.10 FIELD-APPLIED JACKETS

A. Metal Jacket:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
   b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
   c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.

   a. Factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, polysurlyn heat laminated to aluminum jacket
   d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, polysurlyn heat laminated to aluminum jacket
   e. Factory-Fabricated Fitting Covers:

      1) Same material, finish, and thickness as jacket.
      2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.
      8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

   a. Factory cut and rolled to size.
   b. Material, finish, and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, polysurlyn heat laminated to stainless steel jacket
   d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, polysurlyn heat laminated to stainless steel jacket
   e. Factory-Fabricated Fitting Covers:

      1) Same material, finish, and thickness as jacket.
      2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.

5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. ABI, Ideal Tape Division; 428 AWF ASJ.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
c. Compac Corporation; 104 and 105.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches (75 mm).

3. Thickness: 11.5 mils (0.29 mm).

4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.

5. Elongation: 2 percent.

6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.

7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. ABI, Ideal Tape Division; 491 AWF FSK.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
c. Compac Corporation; 110 and 111.
d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches (75 mm).

3. Thickness: 6.5 mils (0.16 mm).

4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.

5. Elongation: 2 percent.

6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.

7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

2.12 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.

3. Stainless Steel: ½ inch wide x 0.020 inch thick Type 304 with wing seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

C. Wire: 0.080-inch (2.0-mm) nickel-copper alloy.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. C & F Wire.

2.13 WEATHERPROOFING FINISHES FOR OUTDOOR INSULATION

A. Outdoor Piping

1. Piping shall be insulated as specified in Part 3 of this Section and provided with a weatherproof finish as described herein.

2. Finish with a metal jacket which has a factory applied moisture barrier. For all applications where it is available, the jacketing shall be factory attached to the insulation and installed per manufacturer's recommendation.

3. Where field applied jacketing must be used, it shall be applied with 2" overlap facing down from the weather and shall be secured with bands compatible with band material and seals applied on 12" centers with bands applied directly over butt overlaps. As an alternate, the jacketing may be applied with Pli-Grip Rivets. Where jacketing is cut out or abuts an uninsulated surface, the joint shall be sealed with Insul-Coustic Sure Joint 405, or BF 30-45 Foam seal.

4. Fittings and valves shall be insulated and finished with mitered sections of the insulation with factory attached metal jackets installed per manufacturer's recommendation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation. Electric pipe heat tracing shall be furnished and installed by the Contractor responsible for the work of Division 26.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Systems operating below 70°F are defined as "below ambient" systems and require continuous vapor barrier protection. Systems operating above 70°F are defined a "above ambient" system.

B. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

C. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

D. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

E. Install insulation with longitudinal seams at top and bottom of horizontal runs.

F. Install multiple layers of insulation with longitudinal and end seams staggered.

G. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

H. Keep insulation materials dry during application and finishing.

I. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

J. Install insulation with least number of joints practical.

K. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

L. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

M. Installation of Type P-1 insulation on “below ambient” concealed and exposed piping system as follows:

1. Insulation for both exposed and concealed piping systems includes and ASJ jacket with pressure sensitive self- sealing lap

2. Longitudinal seams and circumferential joints for systems requiring Type P-1 insulation shall be provided with a continuous vapor barrier for both longitudinal seams and circumferential joints.

3. Butt longitudinal seam of performed pipe insulation tightly

4. Seal self-sealing lap at longitudinal seam in accordance with manufacturer’s recommended procedure. Seal along longitudinal seam shall be continuous to maintain vapor barrier.

5. Butt circumferential joints of adjacent section of insulation tightly

6. Seal circumferential joints with a minimum 3 inch wide pressure self-sealing tape in accordance with manufacturer’s recommendations.. Seal along both sides of circumferential joint shall be continuous to maintain vapor barrier

7. For both longitudinal seams and circumferential joints, verify with Insulation Manufacturer whether vapor barrier mastic is required in addition to self-sealing lap and tape is necessary to maintain vapor barrier.

8. Where multiple layers of insulation are required, the 1st layer of insulation does not require a ASJ jacket. Staggered both longitudinal seams and circumferential joints.

N. Installation of Type P-3 insulation as follows:

1. Slip insulation over pipe prior to being connected.

2. If insulation cannot be installed prior to being connected to system, slit insulation longitudinally and snap insulation over pipe.

3. Install adhesive compatible with insulation along the entire length of longitudinal slit in accordance with manufacturer's recommendations to secure insulation and maintain vapor barrier.

4. For circumferential joints, install adhesive to adjacent sections of pipe insulation in accordance with manufacturer's recommendations and butt tightly to maintain vapor barrier.

O. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

P. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

Q. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

R. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.

2. Testing agency labels and stamps.

3. Nameplates and data plates.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.

4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

C. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

6. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

7. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

8. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations where service of equipment required. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.

4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.

2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.

2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3. Install insulation to flanges as specified for flange insulation application.

4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.

4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

B. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.

2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

C. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.

2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.

3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

4. Install insulation to flanges as specified for flange insulation application.

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.

2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.

3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with bands compatible with metal jacket material 12 inches (300 mm) o.c. and at end joints.

3.9 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range.

B. Pipe Insulation Schedule

PIPE INSULATION SCHEDULE			
PIPING SYSTEM	INSULATION TYPE	INSULATION THICKNESS (INCHES)	REMARKS
Condensate drains from A.C. units, fan coil units, heat pump units, other equipment with cooling coils and miscellaneous drain piping subject to sweating (All Pipe Sizes)	P-1 or P3	1	For horizontal piping at or in ceilings.
Refrigerant Suction Piping	P-1 or P-3	1 1/2	

3.10 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

1. Aluminum; Smooth surface 0.32 inch (0.81 mm) thick for round pipes 24 inches and diameter and smaller; 0.40 inch (1.0 mm) thick for pipes 26 inches and larger

2. Painted Aluminum; Smooth surface 0.32 inch (0.81 mm) thick for pipes 24 inches and diameter and smaller; 0.40 inch (1.0 mm) thick for pipes 26 inches and larger

3. Stainless Steel; Type 304, smooth 2B finish surface 0.20 inch (0.51 mm) thick for pipes 24 inches and diameter and smaller; 0.24 inch (0.51mm) thick for pipes 26 inches and larger

END OF SECTION 23 07 19
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SECTION 23 07 20 - ACOUSTICAL DUCT LINING AND DUCT WRAP

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Ductwork acoustical lining.

B. Ductwork sound barrier acoustical wrap.

1.2 RELATED DOCUMENTS

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

B. Section 23 05 00, Common Work Results for HVAC.

C. Section 23 05 50, Basic Mechanical Materials and Methods.

D. This section is a part of each Division 23.

1.3 REFERENCES

A. ANSI/ASTM C553 - Mineral Fiber Blanket and Felt Insulation.

B. ANSI/ASTM C612 - Mineral Fiber Block and Board Thermal Insulation.

C. ASTM E84 - Surface Burning Characteristics of Building Materials.

D. NFPA 255 - Surface Burning Characteristics of Building Materials.

E. UL 723 - Surface Burning Characteristics of Building Materials.

F. UL 181 – For Erosion Test

1.4 QUALITY ASSURANCE

A. Applicator: Company specializing in ductwork acoustic lining application with three years minimum experience.

1.5 SUBMITTALS

A. Submit product data under provisions of Section 01 30 00.

B. Include product description, list of materials and thickness for each service, and locations.

C. Submit manufacturer's installation instructions under provisions of Section 01 30 00.

D. Approval of the above-named products is contingent upon samples to be submitted to our office. Also, after approval, contractor shall furnish to the job site a section of the material applied to a 24 x 24 section of sheetmetal. This will be maintained at the job site for quality control.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acoustical Duct Lining Materials: The following vendors will be reviewed for approval providing they meet all the performance requirements of the specifications.

a. CertainTeed Corporation; Insulation Group (Ultralite).

b. Johns Manville (Linacoustic).

c. Owens Corning (Aeroflex).

B. Sound Barrier Acoustical Wrapping: The following vendors will be reviewed for approval providing they meet all the performance requirements of the specifications.

1. EAR - TUFCOTE barrier absorber composite;

2. Sound Coat - Soundmat PB embossed;

3. Sound Seal - Barrier/fiberglass Type BSC-25;

4. Kinetics - Barrier composite KBC - 100QQ

5. Substitutions are not acceptable.

2.2 MATERIALS DUCT LINING

A. Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

B. Acoustical Liner R-Values:

1. Where located within a building envelope in unconditioned spaces, acoustic lining shall be 1½ lb. per cubic foot minimum density, with minimum thickness 1½ inches or equivalent R-6 value, unless specified to be greater.

2. Where located outside of building envelope, acoustic lining shall have thermal resistance value of R-8, unless specified to be greater. Coordinate liner thickness with liner manufacturer.

C. Lining shall have a composite fire and smoke hazard rating (UL 723) not exceeding:

Flame Spread: 25

Smoke Developed: 50

D. Asbestos shall not be used in the manufacture of lining products.

E. Include a foil face or barrier against shedding.

F. Solvent or Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

G. All portion of ducts designated to receive duct liner (acoustical) shall

1. Provide complete coverage of sheet metal for designated lengths.

2. Transverse joints shall be neatly butted and there shall not be interruptions or gaps.

3. Black coated surface of duct liner shall face the air stream.

4. Duct liner shall be adhered to sheet metal with 100% coverage of adhesive.

5. All exposed leading edges and all transverse joints shall be coated with adhesive.

6. Duct liner shall be additional secured with mechanical fasteners in accordance with SMACNA HVAC Duct Standards – Metal and Flexible except that gripnails or equivalent shall not be allowed.

7. Duct liner shall be cut to assure overlapped and compressed longitudinal corner joints.

8. Fasteners shall start with in 3” of upstream transverse edges of the liner and 3” from longitudinal joints and spaced as per SMACNA.

H. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) 0.135-inch-(3.5-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

2.3 SOUND BARRIER WRAPPING

A. Ductwork shall be fully wrapped with acoustical barrier/absorber lagging material, as specified herein, as shown on the drawings, or as required.

B. Acoustical barrier/absorber lagging material construction must meet the following requirements:

1. Material to consist of one barrier layer sandwiched between either two sound absorbing layers, or one sound absorbing layer and one decoupling layer.

2. Minimum barrier layer density of 1 lb/ft2

3. Minimum absorber layer thickness of 1" (each layer).

4. Minimum decoupling layer thickness of 1" (each layer).

5. Minimum absorbing layer NRC rating of 0.75.

6. Minimum composite material STC rating of STC-24.

C. Acoustical barrier/absorber lagging material shall meet all applicable flammability, chemical resistance, temperature resistance, and wear requirements.

D. Ducts shall be fully wrapped with lagging material on all sides, leaving no gaps, holes, or open areas exposed. Lagging material may be fixed and sealed with tape meeting all applicable flammability and resistance requirements, or another suitable method as provided or recommended by the lagging manufacturer.

E. Acoustical barrier/absorber lagging submittal drawings shall include the following information:

1. Decoupling and Sound Absorbing layer(s) material and thickness.

2. Barrier layer material, thickness, and density.

3. Overall material construction STC rating and MRC rating.

F. Asbestos shall not be used in the manufacture of wrapping products.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean surfaces before applying adhesives.

3.2 INSTALLATION

A. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 100 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

2. Apply adhesive to transverse edges of liner. Adhesive is not required for transverse edges of liner facing upstream that receives metal nosing.

3. Butt transverse joints without gaps, and coat joint with adhesive.

4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.

5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.

6. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.

7. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

a. Fan discharges.

b. Intervals of lined duct preceding unlined duct.

8. Terminate inner ducts with metal nosing 4 inches upstream and downstream of fire-damper sleeves.

9. Where a duct liner required for thermal insulation or condensation control has been interrupted a duct covering of equal thermal performance shall be installed. Duct covering shall overlap liner 3” on each side.

B. This contractor shall make all necessary repairs to the lining where improperly applied, or damaged.

C. Duct sizes shown on drawings shall be considered as clear inside dimensions.

D. A perforated inner metal liner consisting of 22 ga. galv. steel with 3/32" dia. holes on 3/16" or 1/4" centers or the equivalent aluminum shall be installed in every one of the following conditions. (Fastening for metal liners shall only be by welded stud. Where duct cross section exceeds 48" the top section shall be fastened with twice the number of clips.)

1. Where shown on drawings.

2. Where called for elsewhere in these documents.

3. Where the duct can be walked on, metal liners shall be used on bottom portions.

E. The leading edge of acoustical duct liner (facing into the air flow) of each non abutting section such as the first section facing into the fan or the first section after a sound trap.

F. All portions of duct designated to receive acoustical duct liner shall be completely covered with acoustical duct liner. Transverse joints shall be neatly butted and there shall be no interruptions or gaps. The black coated surface of the acoustical duct liner shall face the air stream. The acoustical duct liner shall be adhered to the sheet metal with 100% coverage of adhesive and all exposed leading edges and all transverse joints coated with adhesive. Adhesive shall conform to Adhesive and Sealant Council Standards for Adhesives for duct liner; ASC-C-7001C-1972. The acoustical duct liner shall be additionally secured with mechanical fasteners (Mechanical fasteners shall conform to Mechanical Fastener Standard MF-1-l971, available from Sheet Metal and Air Conditioning Contractors National Association), except that gripnails or the equivalent shall not be allowed. Acoustical duct liner shall be cut to assure overlapped and compressed longitudinal corner joints. Fasteners shall start within 3" of the upstream transverse edges of the liner and 3" from the longitudinal joints and shall be spaced as recommended by SMACNA.

3.3 SCHEDULE

A. The following items shall be acoustically lined. Where distances of lining are indicated, the intent is that all ductwork in any direction be acoustically lined. Supply ductwork shall not have acoustical lining, unless otherwise noted in plan. (Also refer to note on drawing M-100 for location of insulation and acoustical lining). Duct wrap is not called for on the drawings but acoustical lining is.

DUCT LINER (ACOUSTICAL) SCHEDULE				
DUCT SYSTEM	DUCT LINER THICKNESS (INCHES)	DUCT LINER LENGTH (FEET) (MINIMUM)	DUCT LINER MATERIAL	REMARKS
Supply and return ductwork from DOAS units.	1½	25	Fibrous-Glass Duct Liner	(Not on VRF units, refer to drawing M-100)
Upstream from Exhaust Fan (including) Plenum	1	15	Fibrous-Glass Duct Liner	
Downstream from Exhaust Fans	1	15	Fibrous-Glass Duct Liner	If discharge of the exhaust fan runs through occupied spaces.
Single offset Transfer Ducts	1	Full Length	Fibrous-Glass Duct Liner	
Double offset Transfer Ducts	1	Full Length	Fibrous-Glass Duct Liner	
Where shown drawings	1½	As Detailed	Fibrous-Glass Duct Liner	

END OF SECTION 23 07 20

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SECTION 23 08 00 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.

B. Related Sections:

1. 01 91 13 – General Commissioning Requirements

2. Division 23 Sections

1.3 SCOPE

A. Commissioning requires the participation of Division 23, Mechanical Contractor and Subcontractors, to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 019113. Division 23, Mechanical Contractor and Subcontractors shall be familiar with Section 019113 and the Commissioning Plan issued by the Commissioning Agent (CA) and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.4 SYSTEMS TO BE COMMISSIONED

A. The following Mechanical systems will be commissioned on this project:

1. Air-Cooled Variable Refrigerant Flow Systems (5)

2. Dedicated Outdoor Air Systems (2)

3. Exhaust Fans (3)

4. Electric Unit heaters approximately (6)

5. Electric Floor Mats approximately (13)

6. Electric Radiant Heaters approximately (24)

7. Building Management Systems

8. ECM Motor Controllers

9. Spot checking of air and water balancing readings including total building space pressurization.

10. All Direct Digital Controls (DDC) shall be verified for proper operation as it relates to the above equipment including interfaces for remote monitoring.

1.5 RESPONSIBILITIES

A. Commissioning responsibilities applicable to the Mechanical contractor of Division 23 are as described in Section 019113, Paragraph 1.10-I.

1.6 OPERATION AND MAINTENANCE (O&M) MANUALS

A. Compile and prepare documentation for all equipment and systems covered in Division 23, Mechanical, and deliver to Construction Manager for inclusion in O&M Manuals in accordance with Division 1.

B. Provide the Commissioning Agent with a copy of O&M Manuals for review.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Provide test equipment necessary to fulfill testing requirements of Division 23, Mechanical.

B. Refer to Section 019113 and other Division 23 Sections for additional Division 23, Mechanical requirements.

PART 3 - EXECUTION

3.1 PREFUNCTIONAL CHECKLISTS AND STARTUP

A. Prefunctional tests and checklists (PFT's) are important to ensure that the equipment and systems are connected properly and are operational. PFT's ensure that functional performance testing may proceed without unnecessary delays. The Contractor shall be responsible for performing Prefunctional testing. EVERY piece of equipment receives a full Prefunctional checkout.

B. Division 23, Mechanical, has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting design objectives of Contract Documents. Commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to CA or Owner.

3.2 FUNCTIONAL PERFORMANCE TESTS

A. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to completion of systems or sub-systems at discretion of CA and CM. Beginning system testing before full completion does not relieve Contractor from fully completing system as soon as possible, including prefunctional checklists.

B. Functional performance testing requirements are in addition to and do not replace any testing required by Code or listed elsewhere in Division 23.

C. Functional performance testing procedures will be performed on but not be limited to the following system types and equipment. Final functional testing requirements and procedures will be developed based on approved equipment shop drawings.

1. Air Handling Units

   a. Equipment:

      1) Air Handling Units, DOAS Make-up Air Units

      2) Return Fans

      3) Variable Frequency Drives(s) (VFDs)

      4) Controls for the above

2. Exhaust Systems

   a. Equipment:

      1) Miscellaneous Exhaust Fans

      2) Controls for the above

3. Cooling System

   a. Equipment:

      1) VRF Indoor and Outdoor units

      2) Split Air Conditioning Systems

      3) Control panel and components

4. Heating System

   a. Equipment:

      1) Floor Heaters

      2) Cabinet Heaters

      3) Air Curtain heater

5. Building Management System

   a. Equipment:

      1) Field control panels

      2) Operator workstations

3) File server(s)

4) Verification of controls front end and graphics

3.3 ISSUES AND DEFICIENCIES

A. Refer to Section 019113 for details relating to resolution of issues and deficiencies.

3.4 TRAINING OF OWNER PERSONNEL

A. Contractor shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 019113 for details.

B. Duration of Training: Mechanical Contractor shall provide training on each piece of equipment according to the Div 0 and individual division 23 sections, and comply with the minimum training durations as follows:

System	**Minimum Training Hours**
VRF Heating/Cooling System	4
VRF DOAS Equipment	4
Motor Controllers and VFDs	4
BMS Controls – General	16
Electric Floor Heaters	2
Unit Heaters/Air Curtain Heaters	1
Exhaust Fans	1
Total Training Time	**30 Hours**

END OF SECTION 230800

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SECTION 23 09 00 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control for terminal heating and cooling equipment not supplied with factory-wired controls.

B. Related Sections of Division 23 including the following

1. Section titled “Sequence of Operation for HVAC Controls”

2. Section titled “Control Point List”

3. Applicable Sections of Division 23 for equipment provided with factory mounted controls that interface with the Building Management System (BMS) provided as part of this Section.

4. Applicable Sections of Division 21, 22 & 26 for equipment provided with factory mounted controls that interface with the Building Management System (BMS) provided as part of this Section.

C. General Work Description

1. Building Management System (BMS) controls contractor shall provide:

a. A fully integrated Building Management System (BMS), UL-listed, incorporating Direct Digital Control (DDC) for energy management, equipment monitoring, and HVAC control.

b. Electronic sensors.

c. All actuators for dampers shall be electric. All sensors shall be electric/electronic.

d. All line voltage and low voltage wiring, conduit, panels, and accessories for a complete operational system. All final electrical connections to each standalone DDC Controller.

e. BMS Contractor shall be responsible for all electrical work associated with the BMS and as shown in the contract documents. The BMS contractor shall be responsible for all electrical work associated with any BMS interface to any other systems including but not limited to HVAC and plumbing systems.

f. The BMS contractor shall furnish all wells for water monitoring devices, flow switches, and alarms.

g. A complete operational system including all work as defined in the entire set of drawings and specifications, including but not limited to associated specifications for mechanical and electrical work, all contract drawings, BMS Point List, and remote function schedule.

h. The BMS system as a whole shall have the capability to be easily expanded through the addition of point modules and/or controllers. No equipment shall be installed which cannot, as installed, accommodate an upgrade the entire system by at least 25%. A 25% system upgrade shall include 25% more points (of each type) either via point modules or controllers and 25% more memory capacity for future connections.

i. Provide appropriate labor jurisdiction to mount, wire and pipe airflow measuring stations in the field. Provide manpower as required to meet project schedule.

1.3 TECHNICAL PROPOSALS

A. Technical proposals shall be prepared in accordance with these specifications. Four (4) copies of the proposal shall be submitted with the bid. Proposals that are unbound, loose, loose in a file folder, stapled, stapled in a manila file folder, etc., will not be acceptable. The technical proposal shall include the following data/information as a minimum. The order of listing here is not intended to indicate, nor should it be construed to indicate, the relative importance of the data/information:

1. Information on organizational capability to handle this project (management, personnel, manufacturing, single source responsibility, etc.). Provide an organizational chart of the local factory branch office indicating the project team and each person's role in the project. Provide a resume for each project team member and all management personnel.

2. A comprehensive bar chart project schedule indicating submission of shop drawings, equipment delivery, installation, start-up commissioning, training, milestones, and all critical path tasks.

3. A project specific on-site and off-site training program which demonstrates specification compliance.

4. BMS Configuration as Proposed:

B. Modularity.

C. Provisions against obsolescence due to technological advancement.

D. Detailed description of all operating, command, application and energy management software provided for this project.

E. Provide a riser drawing of the system architecture. The drawing shall indicate the model number, location and service of each primary control panel, secondary control panel, PC workstation and all other network hardware.

F. A complete description of all interface and/or integration packages.

G. Provide a complete submittal of all hardware, software, sensors and end devices (damper operators, airflow stations, etc.).

H. Description of manual override operation and BMS monitoring of manual override operation and BMS monitoring of manual override for each type control point in system.

I. A list of references (include Owner contact name and phone number) for five (5) projects completed by the BMS contractor within the last five years of similar size, schedule and complexity.

J. A line by line BMS specifications concordance summary. The summary shall be in table form and indicate each article and paragraph by number and whether the proposed BMS contractor 'Does Comply' or 'Does Not Comply' with the paragraph. If the item does not comply, the bidder shall provide a written explanation.

K. A signed certificate stating the Contractor 'has read the performance and functional requirements, understands them, and the technical proposal will comply with all parts of the specification' or a signed line by line specification concordance statement. Certificate or statement shall be signed by a person having the authority to guarantee the statement.

1.4 ABBREVIATIONS

A. AACP - Advanced Application Control Panel

B. AI - Analog Input

C. ANSI - American National Standards Institute

D. AO - Analog Output

E. ASCII - American Standard Code for Information Interchange

F. ASCP - Application Specific Controller

G. AWG - American Wire Gauge

H. AWS - Advanced Work Station

I. BMS - Building Management System

J. CAV - Constant Air Volume

K. CPU - Central Processing Unit

L. CRT - Cathode Ray Tube

M. DAC - Digital to Analog Converter

N. DDC - Direct Digital Control

O. DI - Digital Input

P. DO - Digital Output

Q. EEPROM Electronically Erasable Programmable Read Only Memory

R. EMI - Electromagnetic Interference

S. FAS - Fire Alarm Detection and Annunciation System

T. HOA - Hand-Off-Auto

U. IEEE - Institute of Electrical and Electronics Engineers

V. I/O - Input/Output

W. LAN - Local Area Network

X. LCD - Liquid Crystal Display

Y. LED - Light Emitting Diode

Z. NC - Normally Closed

AA. NO - Normally Open

BB. OWS - Operator Workstation

CC. OAT - Outdoor Air Temperature

DD. PC - Personal Computer

EE. POT - Portable Operator's Terminal

FF. PCOW - Personal Computer Operator Workstation

GG. RAM - Random Access Memory

HH. RFI - Radio Frequency Interference

II. RH - Relative Humidity

JJ. ROM - Read Only Memory

KK. RTD - Resistance Temperature Detector

LL. TCP/IP - Transmission Control Protocol/Internet Protocol

MM. UPS - Uninterruptible Power Supply

NN. VAC - Volts, Alternating Current

OO. VAV - Variable Air Volume

PP. VDC - Volts, Direct Current

QQ. WAN - Wide Area Network

1.5 SYSTEM DESCRIPTION

A. General Product Description

1. The building management system (BMS) shall integrate multiple building functions including equipment supervision and control, alarm management, energy management and historical data collection.

2. The building management system shall consist of the following:

a. Distributed control systems complete with all software and hardware functions shall be provided and installed. System shall be completely based on ANSI/ASHRAE Standard 135, BACnet. This system is to control all mechanical equipment, including all unitary equipment such as AC units, etc. and all air handlersand any other listed equipment using native BACnet-compliant components. Non-BACnet-compliant or proprietary equipment or systems (including gateways) shall not be acceptable and are specifically prohibited.

b. The Building Management System (BMS) application program shall be written to communicate specifically utilizing BACnet protocols. Software functions delivered on this project shall include password protection, scheduling (including optimum start), alarming, logging of historical data, full graphics including animation, after-hours billing program, demand limiting, full suite of field engineering tools including graphical programming and applications. Systems using operating systems other than that described above are strictly prohibited. All software required to program application specific controllers and all field level devices and controllers will be left with the owner. All software passwords required to program and make future changes to the system will also become the property of the owner. All software required to make any program changes anywhere in the system along with scheduling, and trending applications will be left with the owner. All software passwords required to program and make future changes to schedules, trends and related program changes will also become the property of the owner. All software required for all field engineering tools including graphical programming and applications will be left with the owner. All software passwords required to program and make future changes to field engineering tools including graphical programming and applications will be left with the owner.

c. Building controllers shall include complete energy management software, including scheduling building control strategies with optimum start and logging routines. All energy management software and firmware shall be resident in field hardware and shall not be dependent on the operator's terminal. Operator's terminal software is to be used for access to field-based energy management functions only. Provide zone-by-zone direct digital logic control of space temperature, scheduling, runtime accumulation, equipment alarm reporting, and override timers for after-hours usage.

d. All application controllers for every air handler, all central plant equipment, and any other piece of controlled equipment shall be fully programmable. Application controllers shall be mounted next to controlled equipment and communicate with building controller via BACnet LAN.

e. Room sensors shall be provided with digital readout that allows the user to view room temperature, view outside air temperature, adjust the room set point within preset limits and set desired override time. User shall also be able to start and stop unit from the digital sensor. Include all necessary wiring and firmware such that room sensor includes field service mode. Field service mode shall allow technician to balance zones and access any parameter in zone controller.

1.6 SEQUENCE OF OPERATION

A. Refer to Division 23 09 10; Section Titled "Sequence of Operations for HVAC Controls" for sequence of operation.

1.7 ACTION SUBMITTALS

A. General

1. Indicate at the beginning of each submittal, all substitutions and deviations from requirements of Contract Documents.

B. Product Data

1. Technical bulletins and catalog data for all equipment and system components. Clearly identify, by use of symbol or tag number, the service of each item. All irrelevant information shall be marked out leaving only pertinent data.

C. Shop Drawings

1. Include a submittal with sample graphics at least two weeks prior to systems going live.

2. Shop drawing submittals shall comply with Division 01 and other specified requirements and shall include sufficient data to indicate complete compliance with Contract Documents. Submission shall be in the form of drawings, brochures, bulletins, catalog data and/or narrative descriptions.

a. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, relays/switches, control panels, and operator interface equipment.

b. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.

c. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

3. Submission shall include, but not be limited to:

   a. Symbol and abbreviation lists.

   b. System block diagram showing quantity and location of personal operator workstation(s), Primary Control Panels, Secondary Control Panels, and locations of power feeds to BMS and other major system components.

   c. Bill of materials of equipment indicating quantity, manufacturer, and model number.

   d. Schematic flow diagrams showing fans, coils, dampers, and control devices.

   e. Wiring Diagrams: Power, signal, and control wiring.

   f. Details of control panel faces, including controls, instruments, and labeling.

   g. Control Damper Schedule each damper provided under this section and the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Duct Size, Damper Size, Mounting, Actuator Type, Leakage Rate and Flow Characteristics.

   h. DDC System Hardware:

      (i) Wiring diagrams for control units with termination numbers.

      (ii) Schematic diagrams and floor plans for field sensors and control hardware.

      (iii) Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

   i. Power wiring diagrams and electrical requirements.

   j. Interfaces (software and hardware) with other equipment provided in other sections of specifications including but not limited to chiller control system.

   k. Narrative description of operation for each system, enumerating and describing the function of each component. Include alarm and emergency sequences, and equipment interlocks.

   l. Description of manual override operation for every input and output point.

   m. Complete input/output point schedule. Identify point function, type and location.

   n. Spare capacity provisions.

   o. Detailed bill of materials.

p. Device mounting details. Include as a minimum:

(i) Sensing elements in ducts and casings.

q. Network architecture (ladder) diagrams including all nodes and interconnections

r. All information required for USGBC LEED Green Buildings Certification pre evaluation including applications and equipment impact on individual attainment of points. Where a specific device may assist in qualification for LEED points indicate and summarize contribution.

s. Details of all interfaces and connections to the work of other trades.

t. Other information as requested herein.

u. Complete full size drawings, 11" x 17" minimum.

4. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.

5. Controlled Systems:

a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.

b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.

c. Written description of sequence of operation including schematic diagram.

d. Points list.

D. Programming

1. Point identification code.

2. System advisory messages, printouts, logging formats.

3. Drawings of system graphics showing monitored points. (Include only if graphics are specified elsewhere in this specification).

4. Software flow-charts for applications and DDC programs.

5. Person machine interface program, including commands, alarm annunciation, logs and programming capabilities.

6. Description of system operation under failure conditions.

E. Samples

1. All wall, pipe and duct sensors.

2. All other devices mounted on finished surfaces.

3. Samples for Verification: For each color required, of each type of thermostat or sensor cover.

4. Damper, panel and sensor tags.

F. Quality Control Submittals

1. UL, FM, CSA listing compliance certificates.

2. Final calibration, commissioning and testing reports.

G. Time Requirements

1. Within thirty (30) days of award of contract manufacturer shall provide schedule of all submittals employing format as provided hereinafter and enumerating all drawings, samples and miscellaneous submittals by name, quantity, etc.

1.8 QUALITY ASSURANCE

A. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

B. All portions of the system must be of the same manufacturer and must be designed, furnished, installed, commissioned and serviced by manufacturer-approved, factory trained employees.

C. Single source responsibility of supplier shall be the complete installation and proper operation of the BMS and control system and shall include debugging and proper calibration of each component in the entire system.

D. Supplier shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.

E. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

F. BMS shall comply with UL 916 PAZX and 864 UDTZ and be so listed at the time of bid.

G. All system components shall be fault-tolerant. System shall include:

1. Satisfactory operation without damage at 110% and 85% of rated voltage and at plus 3 Hertz variation in line frequency.

2. Static, transient and short-circuit protection on all inputs and outputs.

3. Protection for communication lines against incorrect wiring, static transients and induced magnetic interference.

4. Network-connected devices to be AC coupled or equivalent so that any single device failure will not disrupt or halt network communication.

5. All real time clocks and data file RAM to be battery-backed for a minimum 72 hours and include local and remote system low battery indication.

H. The BMS contractor shall be regularly engaged in the design installation and maintenance of BMS systems and shall meet the following qualifications.

1. A minimum of five (5) years of demonstrated technical expertise and experience in the design installation and maintenance of BMS systems similar in size and complexity to this project.

2. A minimum of five (5) years experience installing the control system of the manufacturer that is to be proposed.

3. Shall be a certified-to-install, direct representative of a control system manufacturer that has a minimum of ten (10) years experience producing control systems similar to that which is to be proposed.

4. A maintained service organization consisting of at least eight (8) competent servicemen, within 60 miles of the project site, for a period of not less than four (4) years.

5. The Bidder shall not be considered qualified to bid this project unless they can provide a list of 10 projects, similar in size and scope to this project, completed within the last five (5) years.

I. The system installer shall provide an experienced project manager for this work from beginning of control installation until final completion. The project manager responsible for direct supervision of the design, installation, start-up and commissioning of the BMS as well as attending of project meetings whenever directed by the owner, construction manager, and/or mechanical contractor. It shall not be acceptable to change the project manager after the project has begun and before final completion. If the BMS contractor wishes to change the project manager, the construction manager and/or Owner's representative must be notified immediately and both the new project manager and the previous project manager shall spend 5 consecutive business days together on-site performing a project management switch-over.

J. Comply with all current governing codes, ordinances, and regulations including UL, NFPA, the local Building Code, NEC, etc.

K. The manufacturer of the Building Management System (BMS) shall provide documentation supporting compliance with ISO-9002 (model for Quality Assurance in Production). The intent of this specification requirement is to ensure that the products and services that the manufacturer provides are delivered through a Quality System and Framework that will assure consistence quality through the project.

L. The system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability for any existing control system component including but not limited to Primary Control Panels, Secondary Control Panels, personal operator workstations, and portable operator's terminals, to be connected and directly communicate with any new BMS system equipment without bridges, routers or protocol converters.

1.9 DELIVERY, STORAGE, AND HANDLING

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

1.10 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 26 Section Titled "Lighting Controls" to achieve compatibility with equipment that interfaces with that system.

C. Coordinate equipment with Division 26 Section Titled "Fire Alarm" to achieve compatibility with equipment that interfaces with that system.

D. Coordinate supply of conditioned electrical circuits for control units and operator workstation.

E. Coordinate equipment with Division 26 Section Titled "Panelboards" to achieve compatibility with starter coils and annunciation devices.

1.11 EXTRA MATERIALS

A. Furnish extra materials described below to match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Replacement Materials: Provide one replacement component for each unique control device including as a minimum:

1. Panels:

a. DDC panel board components.

b. Relays.

c. Power supplies and transformers.

2. Field input devices:

a. Space and air temperature sensors.

b. Space and air humidity sensors.

c. Air differential pressure transmitters.

d. Static pressure transmitter.

e. Air differential switch.

f. Freezestat

g. Current switches.

3. Field output devices:

a. Actuators for dampers.

C. Maintenance Materials: Any unique or special tools that are required for proper operation, maintenance and repair as outlined in the system operation, maintenance and repair manuals shall be provided.

D. Provide a complete list of replacement and maintenance materials in the technical proposal.

1.12 RECORD DOCUMENTS

A. Owner's Manual General

1. Submit two (2) draft copies of owner's manuals for review. After review by authorized representative, the contractor shall incorporate review comments and shall submit four (4) interim final copies. Upon completion of project, acceptance of project by the owner, submit six (6) copies of final "as built" manuals and one (1) reproducible copy (3-mil sepia Mylar).

2. Update manuals with modifications made to system during guarantee period. Provide replacement pages or supplements in quantity stated above for "as built" manuals.

3. Assemble owner's manuals into multi-volume sets.

4. Protect each volume with a heavy-duty vinyl plastic binder. Volumes to have plastic printed dividers between major sections and have oversized binders to accommodate up to one inch thick set of additional information.

5. Each binder to be silk screened with project name and volume title on front cover and binder.

6. On the first page of each manual identify with project name, title, owner's name, engineer's name, contractor's name, address and service phone number, and person who prepared manual.

B. Provide an operating manual to serve as training and reference manual for all aspects of day-to-day operation of the system. Include as a minimum:

1. Control flow diagrams for all building systems.

2. Sequence of operation for automatic and manual operating modes for all building systems. The sequences shall cross-reference the system point names.

3. Description of manual override operation of all control points in system.

4. BMS system manufacturer's complete operating manuals.

C. Provide a maintenance manual to serve as training and reference manual for all aspects of day-to-day maintenance and major system repairs. Include as a minimum:

1. Complete as-built installation drawings for each building system.

2. System Operator's manuals including all information required to maintain LEED Green Building certification.

3. Archive copy of all site specific databases and sequences.

4. Network diagrams.

5. Interfaces to all third party products and work by other trades.

6. Overall system electrical power supply scheme indicating source of electrical power for each system component. Indicate all battery backup provisions.

7. Overall system shielding and grounding scheme indicating all major components and ground paths.

8. Drawings showing installation details and locations of equipment.

9. Charts showing normal operating conditions at significant points such as electrical test points.

10. Routine preventive maintenance procedures, corrective diagnostics troubleshooting procedures, and calibration procedures.

11. Parts lists with manufacturer's catalog numbers and ordering information.

12. Lists of ordinary and special tools, operating materials supplies and test equipment recommended for operation and servicing.

13. Manufacturer's operating, set up, maintenance and catalog literature for each piece of equipment.

14. Maintenance and repair instructions.

15. Recommended spare parts.

16. Field test reports.

D. Provide a programming manual to serve as training and reference manual for all aspects of system programming. Include as a minimum include the following:

1. Complete programming manuals and reference guides.

2. Details of any special software packages and compilers supplied with system.

3. Information required for independent programming of system.

4. Point schedule including all points, real and pseudo.

5. Project specific software troubleshooting procedures.

E. Maintenance Data and Operating Instructions:

1. Maintenance and operating manuals in accordance with Section 01 00 00, General Requirements.

a. Prepare data in the form of an instructional manual.

b. Contents: Prepare a Table of Contents for each volume, with each Product or system description identified, in three parts as follows:

(i) Part 1: Directory, listing names, addresses, and telephone numbers of Architect/Engineer, Contractor, Subcontractors, and major equipment suppliers.

(ii) Part 2: Operation and maintenance instructions arranged by system and subdivided by specification section. For each category, identify names, addresses, and telephone numbers of Subcontractors and suppliers. Identify the following:

(a) Significant design criteria.

(b) List of equipment.

(c) Parts list for each component.

(d) Operating instructions.

(e) Maintenance instructions for equipment and systems.

(iii) Part 3: Project documents and certificates, including the following:

(a) Shop drawings and product data.

(b) Certificates.

(c) Photocopies of warranties.

(d) Photocopies of bonds.

2. Contents, Each Volume

a. Table of Contents: Provide title of project; names, addresses, and telephone numbers of Architect/Engineer, Sub-consultants and contractor with name of responsible parties; schedule of products and systems, indexed to content of the volume.

b. For each Product or System: List names, addresses and telephone numbers of Subcontractors and suppliers, including local source of supplies and replacement parts.

c. Product Data: Mark each sheet to clearly identify specific products and component parts, and data applicable to installation. Delete inapplicable information.

d. Drawings: Supplement product data to illustrate relations of components parts of equipment and systems, to show control, flow and wiring diagrams. Do not use Project Record Documents as maintenance drawings.

e. Narrative Text: As required to supplement product data. Provide logical sequence of instructions for each procedure, incorporating manufacturer's instructions.

f. Warranties.

g. Bonds.

3. Manual for Equipment and Systems

a. Each item of equipment and each system: Include description of unit or system and component parts. Identify function, normal operating characteristics, and limiting conditions. Include performance curves, with engineering data and tests, and complete nomenclature and model number of replaceable parts.

b. Panelboard Circuit Directories: provide electrical service characteristics, controls, and communications.

c. Include color-coded wiring diagrams as installed.

d. Operating Procedures: Include start-up, break-in and routine normal operating instructions and sequences. Include regulation, control stopping, shutdown and emergency instructions. Include summer, winter, and any special operating instructions.

e. Maintenance Requirements: Include routine procedures and guide for preventative maintenance and trouble shooting, disassembly repair, and re-assembly instructions; and alignment, adjusting, balancing, and checking instructions.

f. Provide servicing and lubrication schedule for dampers and actuators and list of lubricants required.

g. Include manufacturers printed operation and maintenance instructions.

h. Include sequence of operation by BMS manufacturer.

i. Provide original manufacturer's parts list, illustrations, assembly drawings, and diagrams required.

j. Provide control diagrams by controls manufacturer as installed.

k. Provide BMS contractor's coordination drawings, with color coded control piping diagrams as installed.

l. Provide list of original manufacturers' spare parts, current prices, and recommended quantities to be maintained in storage.

m. Additional requirements as specified in individual Product specification sections.

n. Provide a listing in Table of Contents for design data, with tabbed dividers and space for insertion of data.

4. Instruction of Designated Facility Personnel

a. Before final inspection, instruct Owner's designated personnel in operation, adjustment and maintenance of products, equipment, and systems, at agreed upon times.

b. For equipment requiring seasonal operation, perform instruction for other seasons within six months.

c. Use operation and maintenance manuals as basis for instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.

d. Prepare and insert additional data in Operation and Maintenance manual when need for such data becomes apparent during instruction.

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

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

a. Lubrication Schedule: Indicating type and frequency of lubrication required for dampers and actuators.

b. List of Spares: Recommended for normal service requirements.

c. Parts List: Identifying the various parts of the equipment for repair and replacement purposes.

d. Instruction Books may be standard booklets but shall be clearly marked to indicate applicable equipment.

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

F. Display of Maintenance Instructions

1. One set of operating and maintenance instructions shall be neatly framed behind glass and hung adjacent to the equipment concerned.

G. Record Drawings

1. The BMS contractor shall provide a complete set of "as-built" or record drawings. The drawings shall be prepared and delivered to the architect in an acceptable AutoCAD format.

2. The drawings shall indicate:

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

b. All BMS work installed as a modification or addition to the original design.

c. The dimensional information necessary to delineate the exact location of all wiring runs that are so concealed as to be untraceable by inspection through the regular means of access established for inspection and maintenance. Where shop drawings have been prepared and approved, the "as-built" drawings shall be cross-referenced to the respective shop drawing.

d. All wiring routing locations must be shown.

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

4. The record drawings shall be reproducible as directed.

5. The BMS Contractor shall make arrangements with the Engineer to obtain design drawings on CD ROM disks in AutoCAD format for use as a basis for the "as-built" drawings. These documents remain the property of Cosentini Associates and shall not be used for any other purpose without expressed, written consent. The contractor shall assume all liabilities resulting from unauthorized use or modifications to the drawings.

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

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

a. CAD drawing files on CD ROM disks in AutoCAD format. The version of AutoCAD to be utilized shall be the version in use by the Engineer at the time of the submission.

b. Two (2) sets of reproducible drawings.

c. Three (3) sets of blueprints.

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

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

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

11. The contractor shall provide files on disks in an ASCII format for all schedules, catalog information, installation instructions manuals (information) indexed by system and/or equipment.

12. All equipment and systems require proper identification and tagging, including a system description. This information must be coordinated with all design and shop drawings.

1.13 WARRANTY

A. The Contractor shall warranty the BMS to be free from defects in workmanship and material for a period of one (1) year from the date of acceptance by the Owner. During the warranty period. This contractor shall also provide all system software upgrades during the warranty period upon notice from the owner to Contractor, if the system is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the Owner at the cost of the Contractor.

B. The Contractor shall provide an on-line troubleshooting service during the warranty period. The on-line system shall allow the contractor or Owner's agent the ability to interrogate, troubleshoot and correct warranty defects remotely. This system shall be operational 24 hours a day, 365 days a year. If the local manufacturer's staff cannot resolve the problem, the corporate home office staff shall remotely connect to the system and troubleshoot the warranty defect.

C. The Contractor shall submit a written report within 3 days of all warranty defects, the action taken, and corrections made for each warranty call.

D. Extended Maintenance Contract (Alternates 1 & 2)

1. ALTERNATE 1: The BMS contractor shall provide, as part of the base bid price, a one-year preventative maintenance service contract covering all parts, materials, software, hardware, and all costs to provide software and hardware upgrades during the warranty period. The service contract shall include the following at a minimum:

a. Periodic maintenance (preventive and corrective maintenance). A minimum of one eight (8) hour on-site preventative maintenance days per month shall be provided;

b. Recommended spare parts.

c. Emergency service 24 hours a day, 7 days a week, 365 days per year. Response to emergency calls shall be made within 1 hour by phone and 4 hours on-site. Emergency hours shall not be deducted from preventive maintenance time.

d. 'Dial in Services' for troubleshooting via internet 24 hours a day, 7 days per week, 365 days per year. Maximum contractor response time shall be 2 hours.

2. ALTERNATE 2: The BMS contractor, as an alternate, shall provide a bid price to extend the maintenance service contract and the warranty, as specified herein, for four additional years following the warranty period.

a. The maintenance services to be provided in both the base bid and the alternate bid shall include, but are not limited to, the following: (refer to equipment schedules, and control drawings to point, equipment and systems count).

b. General

(i) All control items are to be maintained even if they were not installed under this contract.

(ii) The following are the minimum services required by the owner. If additional services to maintain the warranty are requested by the manufacturer or contained in the manufacturer's maintenance documentation, these services shall be included in both the base and alternate the bid.

(iii) All maintenance procedures must be as per the manufacturer's recommendation and not void any warranties.

(iv) All maintenance procedures must be performed on all systems and equipment based on good standard industry practices or from the Owner's direction.

(v) The BMS maintenance contractor must coordinate the PM program with any existing or new maintenance management system whether installed by this contractor or others.

(vi) The "Standard Terms and Conditions" for this contract will be provided by the facility.

c. Network

(i) Monthly

(a) The BMS contractor shall provide all software and electronic hardware upgrades as upgrades become available.

(b) Provide newly released software documentation updates, field support and technical bulletins.

(c) Provide operator support in identifying and resolving problems with software, operations or programming.

(ii) Quarterly

(a) Perform diagnostics on the network to analyze trunk traffic and optimize the trunk.

(b) Perform system file back up, field panel database and graphics database backup.

(c) Create or modify operator interface graphics as necessary to reflect changes in the system.

d. Primary, Secondary Control and Application Specific Terminal Equipment Controller (if applicable) Panels

(i) Monthly

(a) Verify regulated power assembly and battery voltages. Adjust if required.

(b) Ensure cabinet is at earth ground potential.

(c) Verify proper system electrical ground isolation.

(d) Inspect interconnecting cables and electrical connections.

(e) Via personal computer user interface, exercise controlled devices with manual command functions and verify proper response of connected field hardware. Check for alarms and overrides using note specific alarms and overrides.

(f) Inspect HOA switches for proper position. Coordinate activation of HOA switch test w/owner.

(g) Perform built-in, field panel diagnostic tests.

(h) Perform integrity test and system wide function test through random point checks, commands, selective disabling, and standard field cabinet reports.

(i) Note system points that are in override condition and review with building engineer.

(j) Note system points that are in alarm condition and review with building engineer.

(k) Review personal computer operator workstation(s) log book with engineer.

(ii) Annually

(a) Clean external surfaces of panel enclosure and associated primary and secondary controllers.

(b) Exercise point value display and run diagnostic self-test on primary and secondary control panels.

(c) Inspect interior surfaces and components of panel enclosure and associated primary and secondary control panels and clean if required. Ensure all mounted devices and plug-in components are securely in place.

(d) Evaluate binary and analog points for proper operation and reporting. At the personal computer operator workstation, make a general performance review of all points.

(e) Check individual critical points. Determine new or revised calibration coefficients as required. Make adjustments to connected field devices as required.

(f) Enter new revised calibration coefficients into software after completing critical point procedures for each primary or secondary control panel.

(g) Upgrade control panel firmware and software with new version as available.

(h) Review control loops for proper operation at a time when controlled conditions are stable and at setpoint. If necessary, verify or adjust tuning constraints (proportional/integral gains, etc.), setpoints, parameters, and/or reset schedules.

(i) Record any parameter values that are different than those shown on program listing.

(j) Label and date all field devices that have been changed or added.

e. All Control Dampers

(i) Semi-Annually

(a) Check damper linkage, setscrews, and blade adjustment for proper tightness. Lubricate as required.

(b) Operate dampers over full modulation range to ensure proper operation. Adjust as required. Repair/replace all defective components.

(c) Inspect condition of damper actuators. Operate actuators over full modulation range to ensure proper operation. Repair/replace all defective components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Electric, Electronic, and DDC Systems:

a. JCI

2.2 SYSTEM ARCHITECTURE

A. The Building Management System (BMS) is designed to support the comfort, safety, and productivity of the building's occupants and property. BMS shall integrate multiple building functions including equipment supervision and control, alarm management, energy management, information management, and historical data collection and archiving.

B. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, network controllers and operator devices, while re-using existing controls equipment.

C. In order to meet these requirements, the BMS must be capable of many methods of integration, at each tier of the network:

D. Owner Intranet Network

1. The BMS contractor shall be responsible for installation of primary and secondary LAN's required to support the complete BMS system. The Operator Interface Panel for the building shall be located as advised by the Project Manager.

E. BACnet Primary LAN

1. Primary LAN for the building automation system shall consist of a high speed network utilizing BACnet over Ethernet or BACnet/IP. The Primary LAN shall be used for communications between BACnet B-BC devices, B-AAC devices, and B-ASC devices.

F. BACnet Secondary LAN

1. A secondary LAN, separate from the Primary LAN shall be used for communications between B-ASC devices and the B-BC or B-AAC that provides BACnet router services for the device. The Secondary LAN shall utilize BACnet MS/TP for communications. The intent of the separate Primary LAN and Secondary LAN is to isolate traffic between B-BC's or B-AAC's and their associated B-ASC devices from the primary LAN.

2.3 OPERATOR INTERFACE

A. Advanced Work Station General

1. General structure of workstation interaction shall be a standard client/server relationship. Server shall be used to archive data and store system database. Thick and Web Clients shall access server for all archived data.

2. BACnet Conformance

a. Advanced Work Station shall be approved by the BTL as meeting the BACnet Advanced Work Station (AWS) requirements.

b. Please refer to Section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

c. Standard BACnet object types accessed by the workstation shall include as a minimum: Analog Value, Analog Input, Analog Output, Binary Value, Binary Input, Binary Output, Calendar, Device, Event Enrollment, File, Notification Class, Program, and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

d. The AWS shall comply with Annex J of the BACnet specification for IP connections. Must support remote connection to server using a thick client application. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN. Must support interoperability on wide area networks (WANs) and campus area networks (CANs). Workstation shall support Foreign Device Registration to allow temporary workstation connection to IP network.

B. Advanced Workstation Hardware

1. Provide One server. The server shall be located as per owner.

2. Advanced workstation shall be provided for command entry, information management, network alarm management and database management functions. All real-time control functions shall be resident in the DDC Controllers to facilitate greater fault tolerance and reliability.

3. The advanced workstation shall be an integrated node on the network and shall allow the operator to view the entire Building Management System network.

4. The monitoring and control functions of the Building Management System (BMS) shall be totally independent of the AWS so that if the Server is off-line (not operating), the Building Management System will continue to perform all of its monitoring and control functions.

5. The AWS Server shall consist (as a minimum) of but not be limited to:

   a. Full tower Case or Rack Mount (Coordinate with owner)

   b. 2 GHz dual-core processor or better

   c. 64-bit OS

   d. 8 GB RAM or better

   e. 80GB hard disk or better

   f. High-performance graphics adapter

   g. Network interface card (100/1000 Mbps)

   h. Keyboard, minimum 23" LCD color monitor, mouse, and DVD-R/W

   i. Color Printer (Inkjet, Color Dye or Laser)

   j. Un-interruptible Power supply

   k. Windows 7, Windows 8, Windows 8.1, Windows Server 2012.

6. The above requirements shall be considered a minimum for the server. The Building Management System manufacturer shall review the above and if not sufficient for the requirements of the project, provide server with sufficient computing capability (including but not limited to processor speed/power, memory, local storage, etc.) to meet the system software minimum requirements, as well as with sufficient video display capabilities.

7. At the conclusion of project, contractor shall leave with owner a CD ROM that includes the complete software operation system and project graphics, set points, system parameters, etc. This backup shall allow the owner to completely restore the system in the case of a computer malfunction.

C. Advanced Workstation Software

1. Data Displays

a. Data displays shall render all data associated with project as called out on drawings and/or object type list supplied. Graphic files shall be created using digital, full color photographs of system installation, AutoCAD or Visio drawing files of field installation drawings and wiring diagrams from as-built drawings.

b. Data displays shall render all data using iconic graphic representations of all mechanical equipment. System shall be capable of displaying graphic file, text, and dynamic object data together on each display and shall include animation. Information shall be labeled with descriptors and shall be shown with the appropriate engineering units. All information on any display shall be dynamically updated without any action by the user.

c. Data display frame shall allow user to change all field-resident AWS functions associated with the project, such as setpoints, weekly schedules, exception schedules, etc., from any screen, no matter if that screen shows all text or a complete graphic display. This shall be done without any reference to object addresses or other numeric/mnemonic indications.

d. Analog objects shall be displayed with operator modifiable units. Analog input objects may also be displayed as individual graphic items on the display screen as an overlay to the system graphic.

e. All displays and programming shall be generated and customized by the local BMS supplier and installer. Systems requiring factory development of graphics or programming of DDC logic are specifically prohibited.

f. AWS shall be supplied with a library of standard graphics, which may be used unaltered or modified by the operator. AWS shall include a library of equipment graphic components to assemble custom graphics. Systems that do not allow customization or creation of new graphic objects by the operator (or with third-party software) shall not be allowed.

g. Data display frame shall include customizable and persistent tree navigation for building, equipment and system diagnostic centric display organization.

h. Each display may be protected from viewing unless operator credentials have the appropriate access level. An access level may be assigned to each display and system object. The menu label shall not appear on the graphic if the operator does not have the appropriate security level.

i. Data displays shall have the ability to link to content outside of the BMS system. Such content shall include but is not limited to: Launching external files in their native applications (for example, a Microsoft Word document) and launching a Web browser resolving to a specified Web address.

j. The AWS shall have the ability to support 20 concurrent web clients

k. Data displays shall support:

(i) Graphic items with custom geometry that offer both color gradient shading and variable opacity in scale to system variables and range set points.

(ii) Clear and custom geometry navigation buttons to provide intuitive navigation

(iii) Graphic files in jpg, png, and .gif file types

(iv) Viewing of 1024 system data points in a single screen

2. Password Protection

a. Provide security system that prevents unauthorized use unless operator is logged on. Access shall be limited to operator's assigned functions when user is logged on. This includes displays as outlined above.

b. AWS shall provide security for a minimum of 200 users. Each user shall have an individual User ID, User Name, and Password. Entries are alphanumeric characters only and are case sensitive (except for User ID). User ID shall be 0–8 characters, User Name shall be 0–29 characters, and Password shall be 4–8 characters long.

c. Each user shall be allowed individual assignment of only those control functions, menu items, and user specific system start display, as well restricted access to *discrete BACnet devices* to which that user requires access.

d. All passwords, user names, and access assignments shall be adjustable online at the operator's terminal.

e. Users shall also have a set access level, which defines access to displays and individual objects the user may control. System shall include 10 separate and distinct access levels for assignment to users.

f. System shall include an Auto Logout Feature that shall automatically logout user when there has been no keyboard or mouse activity for a set period of time. Time period shall be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal shall display message on screen that user is logged out after Auto Logout occurs.

g. The system shall permit the assignment of an effective date range, as well as an effective time of day, that the User IDs are permitted to authenticate.

3. Operator Activity Log

a. Operator Activity Log that tracks all operator changes and activities shall be included with AWS. System shall track what is changed in the system, who performed this change, date and time of system activity, and value of the change before and after operator activity. Operator shall be able to display all activity, sort the changes by user and also by operation. Operator shall be able to print the Operator Activity log display.

b. Log shall be gathered and archived to hard drive on AWS as needed. Operator shall be able to export data for display and sorting in a spreadsheet.

4. Scheduling

a. AWS and Web Client shall show all information in easy-to-read daily format including calendar of this month and next. All schedules shall show actual ON/OFF times for day based on scheduling priority. Priority for scheduling shall be events, holidays and daily, with events being the highest.

b. Holiday and special event schedules shall display data in calendar format. Operator shall be able to schedule holidays and special events directly from these calendars.

c. Operator shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate access privileges.

d. AWS shall include a Schedule Wizard for set up of schedules. Wizard shall walk user through all steps necessary for schedule generation. Wizard shall have its own pull-down selection for startup or may be started by right-clicking on value displayed on graphic and then selecting Schedule.

e. Scheduling shall include optimum start based on outside air temperature, current heating/cooling set points, indoor temperature and history of previous starts. Each and every individual zone shall have optimum start time independently calculated based on all parameters listed. User shall input schedules to set time that occupied set point is to be attained. Optimum start feature shall calculate the startup time needed to match zone temperature to set point. User shall be able to set a limit for the maximum startup time allowed.

f. Schedule list shall show all schedules currently defined. This list shall include all standard, holiday and event schedules. In addition, user shall be able to select a list that shows all scheduled points and zones.

g. Display of all three schedules must show all ON times for standard, holiday and event schedules in different colors on a given day. In addition, OFF times for each must also be shown in additional colors. User shall be able to select from standard calendar what days are to be scheduled and same display shall show all points and zones affected. User shall be able to set time for one day and select all days of the week that shall be affected as a recurrence of that same schedule for that given day.

h. Any displayed data that is changeable by the operator may be selected using the right mouse button and the schedule shall then be selectable on the screen. Selection of the schedule using this method shall allow the viewing of the assigned schedule allow the point to be scheduled.

i. Schedule editor shall support Drag-n-drop events and holidays onto the schedule calendar

j. Schedule editor shall support Drag-n-drop events default to a 2hr period; which can then be adjusted by the user.

k. Schedule editor shall support Drag-n-drop holidays are defaulted for OFF all day and can be edited for multiple-day holidays.

l. Schedule editor shall support the View of affected zones when adding or editing timed events of a schedule.

5. Alarm Indication and Handling.

a. AWS shall provide visual, printed, and email means of alarm indication. Printout of alarms shall be sent to the assigned terminal and port. Alarm notification can be filtered based on the User ID's authorization level.

b. Web client shall display a persistent alarm state for the system regardless of the data view including points in alarm but not acknowledged, and points that have gone into alarm and returned to normal without being acknowledged.

c. Alarm History shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the AWS. Each entry shall include a description of the event-initiating object generating the alarm. Description shall be an alarm message of at least 256 characters in length. Entry shall include time and date of alarm occurrence, time and date of object state return to normal, time and date of alarm acknowledgment, and identification of operator acknowledging alarm.

d. Alarm messages shall be in user-definable text (English or other specified language) and shall be delivered either to the operator's terminal, client or through remote communication using email (Authenticated SMTP supported).

e. AWS shall include an Alarm Wizard for set up of alarms. Wizard shall walk user through all steps necessary for alarm generation. Wizard shall have its own pull-down selection for startup or may be started by right-clicking on value displayed on graphic and then selecting alarm setup.

f. AWS shall support color-coded indication of current alarms as follows:

g. Red indicator shows number of active alarms that have not been acknowledged.

h. Yellow indicator shows number of alarms that are still active but have been acknowledged.

i. Blue indicator shows number of alarms that have returned to normal but have not been acknowledged.

j. Color-coded indicators, when selected by the user, navigate to a pre-filtered view of Alarm History.

k. Alarm history can be filtered by color-coded indicator states.

l. Alarm annunciation includes navigation link to a user selected display or URL.

m. User can silence audible annunciation for the current session.

n. User can disable auto-refresh of alarm annunciation for current session.

o. Any displayed data that is changeable by the operator may be selected using the right mouse button and the alarm shall then be selectable on the screen. Selection of the alarm using this method shall allow the viewing of the alarm history or allow the creation of a new alarm.

6. Trendlog Information

a. AWS shall periodically gather historically recorded data stored in the building controllers and store the information in the system database. Stored records shall be appended with new sample data, allowing records to be accumulated. Systems that write over stored records shall not be allowed unless limited file size is specified. System database shall be capable of storing up to 50 million records before needing to archive data. Samples may be viewed at the web client. Operator shall be able to view all trended records, both stored and archived. All trendlog records shall be displayed in standard engineering units.

b. AWS shall be capable of trending on an interval determined by a polling rate, or change-of-value.

c. AWS shall be able to change Trendlog setup information. This includes the information to be logged as well as the interval at which it is to be logged. All operations shall be password protected. Viewing may be accessed directly from any and all graphics on which a trended object is displayed.

d. AWS shall include a Trendlog Wizard for setup of logs. Wizard shall walk user through all necessary steps. Wizard shall have its own pull-down selection for startup, or may be started by right-clicking on value displayed on graphic, and then selecting Trendlogs from the displayed menu.

e. AWS shall be capable of using Microsoft SQL as the system database.

f. Any displayed data that is changeable by the operator may be selected using the right mouse button and the trendlog shall then be selectable on the screen. Selection of the trendlog using this method shall allow the viewing of the trendlog view.

g. Trendlog viewer shall provide:

(i) Software that is capable of graphing the trend logged object data shall be included.

(ii) Access and ability to create, edit and view are restricted to users by user account credentials

(iii) Specific and repeatable URL defines the trendlog(s) that comprise the view

(iv) Call out of trendlog value at intersection of trend line and mouse-over vertical axis.

(v) Trend log and companion logs can be configured to display on one of two independent vertical scales.

(vi) Click zoom for control of data set viewed along either graph axis.

(vii) User specifiable start and end dates as well as a fast scroll features that that supports click zoom of macro scale view of the data for quickly finding data set based on visual signature.

(viii) User export of the viewed data set to MS Excel.

(ix) Web browser based help

(x) Optional min/max ranges (Upper Control Limits, Lower Control Limits) for each value

7. Energy Log Information

a. AWS shall be capable of periodically gathering energy log data stored in the field equipment and archive the information. Archive files shall be appended with new data, allowing data to be accumulated. Systems that write over archived data shall not be allowed unless limited file size is specified. Display all energy log information in standard engineering units.

b. All data shall be stored in database file format for direct use by third-party programs. Operation of system shall stay completely online during all graphing operations.

c. AWS Operator shall be able to change the energy log setup information as well. This includes the meters to be logged, meter pulse value, and the type of energy units to be logged. All meters monitored by the system may be logged. System shall support using flow and temperature sensors for BTU monitoring.

d. AWS shall display archived data in tabular format form for both consumption and peak values. Data shall be shown in hourly, daily, weekly, monthly and yearly formats. In each format, the user shall be able to select a specific period of data to view.

8. Reports

a. AWS shall be capable of periodically producing reports of trendlogs, alarm history, tenant activities, device summary, energy logs, and override points. The frequency, content, and delivery are to be user adjustable.

b. All reports shall be capable of being delivered in multiple formats including text- and comma-separated value (CSV) files. The files can be printed, emailed, or saved to a folder, either on the server hard drive or on any network drive location.

9. Configuration/Setup

   a. Provide means for operator to display and change system configuration. This shall include, but not be limited to, system time, day of the week, date of daylight savings set forward/set back, printer termination, port addresses, modem port and speed, etc. Items shall be modified using understandable terminology with simple mouse/cursor key movements.

10. Field Engineering Tools

   a. AWS shall include field engineering tools for programming all controllers supplied. All controllers shall be programmed using graphical tools that allow the user to connect function blocks on screen that provide sequencing of all control logic. Function blocks shall be represented by graphical displays that are easily identified and distinct from other types of blocks. Graphical programming that uses simple rectangles and squares is not acceptable.

   b. User shall be able to select a graphical function block from menu and place on screen. Provide zoom in and zoom out capabilities. Function blocks shall be downloaded to controller without any reentry of data.

   c. Programming tools shall include a real-time operation mode. Function blocks shall display real-time data and be animated to show status of data inputs and outputs when in real-time operation. Animation shall show change of status on logic devices and countdown of timer devices in graphical format.

   d. Field engineering tools shall also include a database manager of applications that include logic files for controllers and associated graphics. Operator shall be able to select unit type, input/output configuration and other items that define unit to be controlled. Supply minimum of 250 applications as part of workstation software.

   e. Field engineering tool shall include Device Manager for detection of devices connected anywhere on the BACnet network by scanning of the entire network. This function shall display device instance, network identification, model number, and description of connected devices. It shall record and display software file loaded into each controller. A copy of each file shall be stored on the computer's hard drive. If needed, this file shall be downloaded to the appropriate controller using the mouse.

   f. AWS automatically notify the user when a device that is not in the database is added to the network.

   g. AWS shall include backup/restore function that will back up entire system to selected medium and then restore system from that media. The system shall be capable of creating a backup for the purpose of instantiating a new client PC.

   h. The system shall provide a means to scan, detect, interrogate, and edit third-party BACnet devices and BACnet objects within those devices.

11. WEB Client

    a. BMS supplier shall provide an HTML5 based browser access to the AWS as part of standard installation. User must be able to access all displays of real-time data that are part of the AWS using a standard Web browser. Web browser shall tie into the network through owner-supplied Ethernet network connection. The AWS must be able to support 20 concurrent web client users.

    b. Browser shall be standard version of Microsoft Internet Explorer v10.0 or later, Firefox v19.0 or later and Chrome v24.0 or later. No special vendor-supplied software shall be needed on computers running browser. Data shall be displayed in real-time and update automatically without user interaction.

    c. Web pages shall be automatically generated using HTML 5 from the data display files that reside on the AWS. Any system that requires use of an HTML editor for generation of Web pages shall not be considered.

    d. Access through web client or thick client shall utilize the same hierarchical security scheme as the AWS. User shall be asked to log on once the client makes connection to the AWS. Once the user logs in, any and all changes that are made shall be tracked by the AWS. The user shall be able to change only those items he or she has authority to change. A user activity report shall show any and all activity of the users who have logged in to the system, regardless of whether those changes were made using a web client, thick client or through the AWS.

12. Backup / Restore

    a. At the conclusion of project, contractor shall leave with owner a CD ROM that includes the complete software operation system and project graphics, set points, system parameters, etc. This backup shall allow the owner how to completely restore the system in the case of a computer malfunction.

D. Portable Operator's Terminal

1. The portable operator' terminals (POT) shall be a portable personal computer (PC) with an integral display, keyboard and drives. A communication connection shall be provided at each Personal Computer Operator Workstation, each Primary Control Panel and each Secondary Control Panel to provide the operator with operator to view the entire Building Management System network. In addition, a communication connection shall be provided at each Application Specific Terminal Equipment Controller for connection of the POT.

2. The monitoring and control functions of the Building Management System (BMS) shall be totally independent of the Personal Computer Workstation so that if the Personal Computer is off line (not operating), the Building Management System will continue to perform all of its monitoring and control functions.

3. When connected to a Personal Computer Operator Workstation, a Primary Control Panel or a Secondary Control Panel, the Portable Operator's Terminal shall be to control and monitor all of the functions that can be performed at the Personal Computer Operator Workstation.

4. The portable operator's terminal shall include a user-friendly, English language-prompted interface for quick access to system information.

5. The following criteria for the portable operator's terminal shall be a minimum and shall include but not be limited to:

   a. Latest Pentium processor with a minimum speed of 4.0 GHz or equal alternate manufacturer

   b. 120 Gigabyte hard disk

   c. 2 GB SDRAM memory

   d. Internal Ethernet adapter

   e. Internal Wireless adapter

   f. Minimum 15 inch integral display

   g. Internal 8 x Speed DVD/CD ROM drive

   h. Integral keyboard with full ASCII character set

   i. Portable operator's terminal shall be powered by 120 VAC @ 60Hz and internal rechargeable batteries with a minimum of 4 hours of operation at full power.

   j. Carrying Case designed to accommodate and protect operator's terminal.

   k. The above requirements shall be considered a minimum for each Portable operator's terminal. The Building Management System manufacturer shall review the above and if not sufficient for the requirements of the project, provide portable operator's terminal with sufficient computing capability (including but not limited to processor speed/power, memory, local storage, etc.) to meet the system software minimum requirements, as well as with sufficient video display capabilities.

6. Software for the Portable Operator's Terminal shall be Windows 7, Windows 8, or Windows 8.1.

7. Functionality of the portable operator's terminal connected at any Control Panel, or Controller

   a. Logon to system using same operator passwords utilized with PC operator workstation(s) and/or remote modem(s).

   b. Access all network information from Control Panels, if authorized by password level.

   c. Display all point, selected point, and alarm point summaries.

   d. Display all trending and totalization information.

e. Add, modify, and/or delete any existing or new system point.

f. Command, change set point, enable/disable any system point.

g. Acknowledge all alarms.

h. Connect to local logging and report printer.

8. Simultaneous connection of all POTs to any control panel shall not:

a. Interrupt or interfere with normal network operation in any way.

b. Prevent alarms from being transmitted.

c. Preclude any centrally-initiated commands and/or system modification.

2.4 CONTROLLERS

1. BUILDING CONTROLLER

a. General Requirements

(i) BACnet Conformance

(a) Building Controller shall be approved by the BTL as meeting the BACnet Building Controller requirements.

(b) Please refer to section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

(ii) Building controller shall be of scalable design such that the number of trunks and protocols may be selected to fit the specific requirements of a given project.

(iii) The controller shall be capable of panel-mounted on DIN rail and/or mounting screws.

(iv) The controller shall be capable of providing global control strategies for the system based on information from any objects in the system, regardless if the object is directly monitored by the building controller module or by another controller.

(v) The controller shall be capable of running up to six independent control strategies simultaneously. The modification of one control strategy does not interrupt the function or runtime others.

(vi) The software program implementing the DDC strategies shall be completely flexible and user-definable. All software tools necessary for programming shall be provided as part of project software. Any systems utilizing factory pre-programmed global strategies that cannot be modified by field personnel on-site, using a WAN or downloaded through remote communications are not acceptable. Changing global strategies using firmware changes is also unacceptable.

(vii) Programming shall be object-oriented using control function blocks, and support DDC functions, All flowcharts shall be generated and automatically downloaded to controller. Programming tool shall be supplied and be resident on workstation. The same tool shall be used for all controllers.

(viii) Programming tool shall provide means to graphically view inputs and outputs to each program block in real-time as program is executing. This function may be performed using the operator's workstation or field computer.

(ix) Controller shall have 6000 Analog Values and 6000 Binary Values

(x) Controller IP configuration can be done via a direct USB connect with a operator's workstation or field computer.

(xi) Controller shall have at a minimum a Quad Core 996Ghz processor to ensure fast processing speeds.

(xii) Global control algorithms and automated control functions shall execute using a 64-bit processor.

(xiii) Controller shall have a minimum of 1 GB of DDR3 SDRAM on a 533Mhz bus to ensure high speed data recording, large data storage capacity and reliability.

(xiv) Controller shall support two on-board EIA-485 ports capable of supporting various EIA-485 protocols including but not limited to BACnet MS/TP and Modbus.

(a) Ports are capable of supporting various EIA-485 protocols including but not limited to BACnet MS/TP and Modbus.

(xv) Controller shall support two gigabit speed Ethernet (10/100/1000) ports.

(a) Ports are capable of supporting various Ethernet protocols including but not limited to BACnet IP, FOX, and Modbus.

(xvi) All ports shall be capable of having protocol(s) assigned to utilize the port's physical connection.

(xvii) The controller shall have at a minimum four onboard inputs, two universal inputs and two binary inputs.

(xviii) Schedules

(a) Building controller modules shall provide normal seven-day scheduling, holiday scheduling and event scheduling.

(b) Each building controller shall support a minimum of 380 BACnet Schedule Objects and 380 BACnet Calendar Objects.

(xix) Logging Capabilities

(a) Each building controller shall log as minimum 2000 objects at 15 min intervals. Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.

(b) Logs may be viewed both on-site or off-site using WAN or remote communication.

(c) Building controller shall periodically upload trended data to networked operator's workstation for long-term archiving if desired.

(d) Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.

(xx) Alarm Generation

(a) Alarms may be generated within the system for any object change of value or state (either real or calculated). This includes things such as analog object value changes, binary object state changes, and various controller communication failures.

(b) Each alarm may be dialed out as noted elsewhere.

(c) Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site using remote communications.

(d) Controller must be able to handle up to 2000 alarm setups stored as BACnet event enrollment objects, with system destination and actions individually configurable.

b. BACnet MS/TP

(i) BACnet MS/TP LAN must be software-configurable from 9.6 to 115.4Kbps

(ii) Each BACnet MS/TP LAN shall support 64 BACnet devices at a minimum

(iii) All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

c. BACnet IP

(i) The building controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN.

(ii) Must support interoperability on WANs and CANs and function as a BACnet Broadcast Management Device (BBMD).

(iii) Each controller shall support at a minimum 128 BBMD entries

(iv) BBMD management architecture shall support 3000 subnets at a minimum

(v) Shall support BACnet Network Address Translation

(vi) All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

d. Expansion Ports

(i) Controller shall support two expansion ports.

(a) Combining the two on-board EIA-458 ports with fully loaded expansion ports the controller shall support 6 EIA-485 trunks simultaneously

(ii) Expansion cards that mate to the expansion ports shall include:

(a) Dual port EIA-485 card

(b) LON network card

e. Niagara Framework

(i) Controller shall utilize the Tridium Niagara Framework

(ii) Niagara Framework shall be version 3.8 or newer

(iii) All Niagara licensing shall be stored on a removable MicroSD card for fast in field replacement of controller

(iv) The Niagara License for the controllers shall be an open license

(v) The controller shall be programmable via Niagara Workplace programming tool

(vi) The controller shall be programmable via an Niagara embedded Workplace programming tool

f. Power Supply

(i) Input for power shall accept between 17¬–30VAC, 47–63Hz.

(ii) Optional rechargeable battery for shutdown of controller including storage of all data in flash memory

(iii) On-board capacitor will ensure continuous operation of real-time clocks for minimum of 14 days.

g. Controller shall be in compliance with the following

(i) UL 916 for open energy management

(ii) FCC Class B

(iii) ROHS

(iv) IEC 60703

(v) C-Tick Listed

h. Controller shall operate in the following environmental conditions:

(i) -4 to 149 °F (-20 to 65 °C) without optional battery, or 32 to 122 °F (0 to 50 °C) with optional battery

(ii) 0 to 95% RH, non-condensing

B. Advanced Application Control Panel

1. Control of AO's and BO's and monitoring of AI's and BI's are permitted on devices that conform to the requirements for the BACnet Advanced Application Controller (B-AAC) as identified in ASHRAE Standard 135. B-ASC's shall be provided with all supporting BACnet services as a local function. The device shall not depend upon any other devices for the functionality of schedule or alarm activities. Alternatively, the B-ASC's or B-BC's that the device is dependent upon shall utilize an Uninterruptible Power Supply (UPS). A single piece of equipment shall utilize a single controller. Control functions for a single piece of equipment may not be divided among controllers.

2. The Primary system control by Advanced Application Control Panels shall include but not be limited to:

a. VRF systems

b. Air Handling Units

c. Exhaust Fans

3. The intent of this specification is that the loss of any one Advanced Application Control Panel shall affect only points connected to that specific panel and shall not affect any other HVAC system.

4. Advanced Application Control Panels shall be installed with spare points (minimum of 10 percent of each type) and spare memory capacity for future connections. Provide all hardware software, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

5. Provide all necessary hardware for a complete operating system as required. All hardware shall reside in each Advanced Application Control Panel. Advanced Application Control Panels shall not be dependent upon any higher level computer or another controller for operation.

6. Each Advanced Application Control Panel shall, at a minimum, be provided with:

   a. Appropriate NEMA rated enclosure.

   b. Power supplies as required for all associated modules, sensors, actuators, etc.

   c. Input/output point modules as required including spare capacity.

   d. Monitoring of all industry standard types of analog and digital inputs and outputs.

   e. Each Advanced Application Control Panel shall continuously perform self-diagnostics on all hardware and network communications.

   f. Each Advanced Application Control Panel shall provide battery backup to support the real-time clock and all memory and programs for a minimum of 72 hours.

   g. Each Advanced Application Control Panel shall support firmware upgrades without the need to replace hardware.

   h. Each controller shall support its associated secondary network(s).

   i. Isolation shall be provided at all Advanced Application Control Panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

7. Advanced Application Control Panel Software

   a. Provide all necessary software for a complete operating system as required. All software shall reside in each Advanced Application Control Panel. Advanced Application Control Panels shall not be dependent upon any higher level computer or another controller for operation.

b. All points, panels and programs shall be identified by a point descriptor. The same names shall be displayed at both the Advanced Application Control Panel (s) (via portable terminal, printer or modem) and the PC operator workstation(s). In addition to the point's descriptor and the time and date, the user shall be able to print, display or store an alarm message to more fully describe the alarm condition or direct operator response. Alarm messages shall be coordinated with the Owner.

c. All digital points shall have a user-defined, two-state status indication.

d. Each Advanced Application Control Panel shall, at a minimum, be provided with software for:

(i) Two-position control, proportional control, proportional plus integral control, proportional, integral, plus derivative control algorithms, all with automatic control loop tuning.

(ii) Limiting the number of times each piece of equipment may be cycled within any one-hour period.

(iii) The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads. Upon the resumption of power, each DDC Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

(iv) Energy management routines including time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start-stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating / cooling interlock, supply temperature reset, priority load shedding, and power failure restart.

(v) Custom, job-specific processes defined by the user, to automatically perform calculations and special control routines and sequences of operations.

(a) It shall be possible to use any system measured point data or status, any system calculated data, a result from any process or any user-defined constant in any controller in the system.

(b) Any process shall be able to issue commands to points in any and all other controllers in the system.

(c) Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.

(d) The custom control programming feature shall be documented via English language descriptors.

(vi) Generate and receive automatic and manual operator messages and advisories.

(vii) Interactive HELP function to assist operators connected via POTs and modems.

(viii) Comment lines for all programs.

(ix) Distributed, independent alarm analysis and filtering. Reporting of selected alarms during system shutdown and start-up shall be automatically inhibited. A minimum of six priority levels shall be provided for each point.

(x) Automatically accumulate and store run-time hours for all digital points.

(xi) Automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and pulse input type points.

e. Trend data shall be stored at the Primary Control Panels and automatically uploaded to the PC workstation. All trend data shall be available for use in any 3rd party personal computer applications located in the BMS

f. Advanced Application Control Panels shall be able to assign password access and control priorities. The logon password (at any PC workstation(s) or portable operator terminal) shall enable the operator to monitor, adjust and/or control only the systems, programs, primary control panel, and/or secondary control panels that the operator is authorized for. Passwords and priority shall be fully programmable and adjustable.

g. Advanced Application Control Panels shall be able to access any data from, or send control commands and alarm reports directly to, any other Advanced Application Control Panel or combination of controllers on the network without dependence upon a central or intermediate processing device. Advanced Application Control Panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device.

h. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.

(i) All alarm or point change reports shall include the point's English language description and the time and date of occurrence.

(ii) The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. Priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

(iii) Alarm reports and messages will be directed to a user-defined list of operator devices or PC's.

(iv) In addition to the point's descriptor and the time and date, the user shall be able to print, display or store the alarm message to more fully describe the alarm condition or direct operator response.

(v) Each DDC Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assignable to any number of points in the Controller.

i. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for all points.

(i) DDC Controllers shall store point history data for selected analog and digital inputs and outputs:

(a) Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of l minute to 7 days shall be provided.

(b) Trend data shall be stored at the DDC Controllers and automatically uploaded to the workstation. Uploads shall occur based upon user-defined interval, manual command or automatically. All trend data shall be available for use in any 3rd party personal computer applications.

(c) DDC Controllers shall also provide high resolution sampling capability for verification of control loop performance.

j. DDC Controllers shall automatically accumulate and store run-time hours for all digital input and output points.

k. DDC Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.

l. DDC Controllers shall count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly and monthly basis for all points

m. If the AACP supports a secondary network, provide necessary interface cards at the AACP

n. Failure of any AACP, shall be reported at the PCOW as a critical alarm.

o. Failure of a AACP shall not effect the operation of any other control panels or controllers connected to the network.

p. AACP shall include but not be limited to the following application package as determine by the Building Management System architecture (Option 1 or Option 2) for analysis, storage, retrieval and presentation of data

(i) Monitoring and control software

(ii) Alarm notification

(iii) Graphical Display

(iv) Dynamic Graphical Trending

(v) Historical Data Trends

(vi) Psychometric Properties

(vii) Equipment Run-time Totalization

(viii) Energy Usage and Demand

(ix) Thermal Energy Usage

(x) Measurement and Verification Data (Graphical display and reporting to meet requirements of LEED)

C. Application Specific Controllers

1. Control of AO's and BO's and monitoring of AI's and BI's are permitted on devices that conform to the requirements for the BACnet Application Specific Controller (B-ASC) as identified in ASHRAE Standard 135. Where B-ASC's are utilized, any supporting B-BC or B-ASC must be provided with an Uninterruptible Power Supply (UPS) to avoid any unintentional loss in the support of BACnet services due to a power outage for the B-BC while the B-ASC is functional.

2. Application Specific Controller (ASC) for terminal equipment only. The terminal equipment shall include but not be limited to:

a. Fan Coil (AC) Units

b. Fans with start/stop requirements only (3 fans maximum)

c. Unit Heaters, Cabinet Heaters, etc. (if control from the BMS is required)

d. Electric Duct Heaters

e. All other types of equipment shall be controlled by panels meeting the requirements for ASC.

3. The intent of this specification is that the loss of any one Application Specific Controller shall affect only points connected to that specific Application Specific Controller and shall not affect any other HVAC system Application Specific Controller Application

4. Application Specific Controller (ASC) Hardware

a. All Application Specific Controllers shall be installed with spare points (minimum 10 percent of each type) and spare memory capacity for future connections. Provide all hardware software, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

b. Provide all necessary hardware for a complete operating system as required. All hardware shall reside in each Application Specific Controller. Application Specific Controllers shall not be dependent upon any higher level computer or another controller for operation.

c. Failure of the ASC shall be reported as a critical alarm to the AWS.

d. ASC associated with terminal equipment that has its own electrical power shall be powered from the equipment served. ASC associated with terminal equipment that does not have a power supplied, shall have its own electrical power supply.

e. Provide each ASC with its own software time clock synchronized from the real-time clock at the AACP

f. Battery back-up for volatile memory and software time clock. Battery back-up for each shall have a minimum of 72 hours at full operation and a minimum of five (5) year life and readily field replaceable.

g. Where required by control panel application, interfaces to field instrumentation, final control sequences, etc. shall be provided a Input/output modules that

(i) Enable the AACP to receive signals from digital and analog instrumentation.

(ii) Enable the AACP to output control signals to the final control sequence.

Input/output module shall be either integral with the controller board or a plug-in type module

Input/output module accommodate

(iii) Analog and Digital inputs

(iv) Analog and Digital outputs

(v) Pulse Input

Input/output modules shall include troubleshooting LED indicators

h. ASC shall include a connection port to allow for the connection of either a HHOI Device. For equipment controlled by a ASC that is concealed or above a hung ceiling, connection port shall also be provided at room temperature sensor.

i. ASC shall include all appurtenances (relays, pressure transducers, transformers, etc.) required to perform specified control sequences.

j. All application programs and operating sequence shall reside in the ASTEC however, data based changes shall be initiated from the AWS or HHOI Device.

D. Application Specific Control (ASC) Software

1. Provide all necessary software for a complete operating system as required. All software shall reside in each Application Specific Control Panel. Application Specific Control Panels shall not be dependent upon any higher level computer or another controller for operation.

2. All points, panels and programs shall be identified by a point descriptor. The same names shall be displayed at both the Application Specific Control Panel(s) (via portable terminal, printer or modem) and the PC operator workstation(s). In addition to the point's descriptor and the time and date, the user shall be able to print, display or store an alarm message to more fully describe the alarm condition or direct operator response. Alarm messages shall be coordinated with the Owner.

3. All digital points shall have a user defined, two state status indication.

4. ASC shall include but not be limited to the following application package as determine by the Building Management System architecture for monitoring and control, operating sequences, analysis, storage, retrieval and presentation of data:

a. Monitoring and Control Software

b. Alarm Notification

c. Graphical Display

d. Dynamic Graphical Trending

e. Equipment Run-time Totalization

f. Energy Usage and Demand

g. Thermal Energy Usage

h. Measurement and Verification Data (Graphical display and reporting to meet requirements of LEED)

5. Each Application Specific Controller shall continuously perform self-diagnostics on all hardware and secondary network communications. The ASC shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failure to establish communication to the system.

2.5 INPUT DEVICES

A. General

1. All devices and equipment shall be approved for installation.

2. Provide the following field devices as required by the monitoring, control and optimization functions listed elsewhere in this specification.

3. All sensor signals shall be via a 4-20 ma loop.

B. Analog Inputs

1. Temperature Sensors (Not Including Space Temperature Sensors)

a. All temperature sensors shall use RTD (Resistance Temperature Detector) elements. All control signals shall be via a 4-20 ma loop.

b. Calibration adjustments: Zero & Span.

c. Any point, physical or calculated may be designated for trending.

d. Range:

(i)	Liquid Immersion Temperature	+20/+120 F, +70/+220 F
(ii)	Duct (Single Point) Temperature	+20/+120 F, +70/+220 F
(iii)	Duct (Averaging) Temperature	+20/+120 F
(iv)	Outside Air Temperature	-50/+122 F

e. Outside air temperature sensor shall include

(i) Ventilated sun shield

(ii) Weatherproof enclosure with conduit fitting

(iii) Accuracy; ± 1.0°F

(iv) Sensor length 3 inches

(v) Stainless steel probe with nickel or platinum sensor element

f. Duct mounted (single point) temperature sensor shall include

(i) Length; 2/3rd of the duct width but not less than 12 inches

(ii) Stainless steel probe with nickel or platinum sensor element

(iii) Moisture/waterproof enclosure with conduit fitting

(iv) Accuracy; ± 1.0°F

g. Duct mounted (averaging) temperature sensor shall include

(i) Length one linear foot per square foot of duct cross-section but not less than 12 feet. Where sensor required length exceeds standard manufacturer's length, provide multiple sensors in a series-parallel network arrangement.

(ii) Protected probe with nickel or platinum sensor element

(iii) Moisture/waterproof enclosure with conduit fitting

2. Space Temperature Sensors

a. RTD or thermistor type

b. Accuracy: +0.5 F

c. Operating Range: 80 Degree Range Maximum

d. Set point Adjustment Range: 55 to 95 F

e. Shall include a terminal jack integral to the sensor assembly to allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator's terminal (POT) or hand held operator interface (HHOI) device.

f. Concealed set point adjustment switch with software limits.

g. Push-button override switch. The override switch may be locked out, overridden, or limited as to time through software by an authorized operator.

h. Room sensors shall not be located on outside walls.

i. The length of wiring from the space temperature sensor to the controller shall not exceed 100 ft.

j. Temperature sensors shall be reviewed and approved by owner and architect for finish and style selection.

3. Outdoor Relative Humidity Sensor

a. Housing sensor design to shield from the effects of wind and sun and to allow maximum airflow over the sensor

b. Weatherproof ABS plastic enclosure (NEMA 4 rating)with conduit fitting

c. Proportional 4 to 20 mA for a relative humidity range of 5 to 100 percent

d. Temperature operating range for sensor -4°F below to 140°F

e. Accuracy; ± 3.0 percent over full relative humidity range @ 68°F.

f. Stability; ± 2.0% RH over two years

g. Resolution; 0.1% RH

h. Temperature Dependence; <± 1.5% RH from 14°F to 140°F

i. Furnish Automation Components Inc. A/RH series, Amphenol GEH3 series or equal as approved by engineer.

4. Duct Mounted Relative Humidity Sensor

a. Moisture/waterproof plastic enclosure with conduit fitting

b. Corrosion resistance probe with Proportional 4 to 20 mA for a relative humidity range of 5 to 100 percent

c. Operating Range of sensor 32°F to 125°F; 0 to 100% with maximum dew point 85°F.

d. Accuracy; ± 2.0 percent over a range of 20 to 80 % and ± 4.0 percent 10 to 20 % and 80 to 90%

e. Repeatability; 0.5%

f. Drift; 2.0% over 5 years

g. Duct Probe; 95 -5V flammability per UL 94

h. Duct Probe Length; As required for width of duct or minimum 6.25 inches

i. For Duct Mounted Relative Humidity Sensor that is used as a high limit, provide relay and fixed differential to signal BMS on high duct humidity.

j. Certified compliant with National Institute of Standards and Technology (NIST) guidelines

k. Furnish Automation Components Inc. A/RH series, Amphenol GEH3 series or equal as approved by engineer.

5. Wall Mounted Relative Humidity Sensor

a. Moisture/waterproof PC/ABS plastic enclosure with conduit fitting

b. Corrosion resistance probe with Proportional 4 to 20 mA for a relative humidity range of 5 to 100 percent

c. Operating Range of sensor 32°F to 122°F; 0 to 100% with maximum dew point 85°F.

d. Accuracy; ± 2.0 percent over a range of 20 to 80 % and ± 4.0 percent 10 to 20 % and 80 to 90%

e. Response Time; within 5% RH of actual within 15 minutes

f. Certified compliant with National Institute of Standards and Technology (NIST) guidelines.

g. Furnish Automation Components Inc. A/RH series, Amphenol GEH3 series or equal as approved by engineer.

6. Dew Point Sensors

a. Accuracy: + 2.0 Fdp

b. Range: -40/+115 F DP

c. Furnish Vaisala, Amphenol or equal as approved by engineer.

7. Air Differential Pressure Sensor

a. Range

(i) Duct Mounted Sensor; 0.05 to 2.0 0.05 to 3.0 inches wg Static Pressure

(ii) Room Sensors; -0.1 to +0.1 -0.5 to +0.5 -1.0 to +1.0 wg inches Static Pressure

(iii) Filter Monitoring; Range as required for fan application; Adjustable Set point; differential pressure

(iv) For applications with negative to positive pressure ranges, provide an "elevated Zero" at midpoint of pressure range.

b. Transmitter Output Signal; 4 to 20 mA or 0 to 10 VDC proportional to pressure input range

c. Transmitter Operating Range; 32°F to 125°F

d. Transmitter Span or zero adjustment; accessible with a 20-turn potentiometer for fine resolution.

e. Transmitter Accuracy; ± 1% of span (including non-linearity and hysteresis)

f. Pressure Sensing Element; Differential capacitance cell or piezoresistive (silicon) sensors for pressure measurements

g. Transmitter ports shall include air filter

h. Transmitter monitoring for fan shut down, provide where require two normal closed SPST contactors. One for alarm and one for fan shut down. Contactors shall be rated for fan controller requirements but not less than 10 amps @ 120 volts

i. Transmitter monitoring for fan status, provide where require two normal closed SPST contactors. Contactors shall be rated for fan controller requirements but not less than 10 amps @ 120 volts

j. Transmitter Inlet Ports; ¼ inch suitable for piping from transmitter to static pressure sensor

k. Where required, transmitter shall be UL approved

l. Transmitter shall be capable accepting pressure signals as following depending on application:

(i) Positive pressure only

(ii) Negative Pressure only

(iii) Two Positive Pressure

(iv) Two Negative Pressure

(v) One Positive Pressure and One Negative

m. Static Pressure Sensor (Duct)

(i) ¼ inch stainless steel tube with a minimum or 4 radially drilled sensing holes suitable for duct velocities of 12,000 FPM

(ii) Insertion depth; 6 inch for ductwork less than 20 inches; 12 inch for ductwork 20 inches and greater.

(iii) Provide mounting flange with gasket

(iv) For room pressure sensors, provide stainless steel pressure sensor for direct mounting to wall or mounted to a standard electrical box.

(v) For room pressure sensors and outdoor pressure sensors, provide surge dampers to overcome sudden pressure changes due to wind gust or opening and closing of doors.

(vi) Total Pressure Sensor; where required, provide a ¼ inch stainless steel tube with a single sensing opening facing direction of flow. Insertion depth same as described above.

(vii) Tubing Length & Diameter; Diameter of tubing between transmitter and sensor per manufacturer's recommendation for installation distance

8. Airflow Measurement Devices (AMD)

a. Provide one Airflow Measurement Device (AMD) for each measurement location provided on the plans, specifications, schedules and/or control diagrams to determine the average airflow rate and temperature at each measurement location.

b. Each AMD shall be provided with a microprocessor-based transmitter and one or more sensor probes.

c. Products described in this subparagraph shall be Listed and labeled in accordance with the UL and having been tested in accordance with standard UL 873 – Airflow Indicating Equipment as a complete and functional assembly by an independent testing agency. The AMD shall be BTL Listed.

d. Measurement devices included in this subparagraph

(i) Duct and plenum mounted airflow measurement devices

(ii) Fan inlet mounted airflow measurement devices

e. Subject to compliance with performance and design requirements of this Section, provide products that comply with this specification by one of the following vendors:

(i) EBTRON, Inc. Model GTx116-P+ (basis of design)

(ii) Kurz Instrument

(iii) Fluid Components International (FCI)

f. Airflow measurement devices shall use the principle of thermal dispersion and provide one self-heated bead-in-glass thermistor and one zero power bead-in-glass thermistor at each sensing node.

g. Fan Inlet measurement devices shall not be used unless indicated on drawings or required by these specifications. Fan Inlet measurement devices shall not be substituted for duct and plenum measurement devices.

h. Sensor Probes

(i) Sensor probes shall be constructed of gold anodized, 6063 aluminum alloy tube insert 316 stainless steel tube in lieu of 6063 aluminum alloy tube, when required.

(ii) Sensor probe mounting brackets shall be constructed of 304 stainless steel.

(iii) Probe internal wiring between the connecting cable and sensor nodes shall be Kynar coated copper.

(iv) PVC jacketed internal wiring is not acceptable.

(v) Probe internal wiring connections shall consist of solder joints and spot welds.

(vi) Connectors of any type within the probe are not acceptable.

(vii) Printed circuit boards within the probe are not acceptable.

(viii) Probe internal wiring connections shall be sealed and protected from the elements and suitable for direct exposure to water.

(ix) Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/CUL Listed cable rated for exposures from -67°F to 392 °F (-55° C to 200° C) and continuous and direct UV exposure.

(x) Plenum rated PVC jacket cables are not acceptable.

(xi) Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.

(xii) Each sensor probe shall contain one or more independently wired sensing nodes.

(xiii) Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable connecting plug and not require matching or adjustments to the transmitter.

(xiv) Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy.

(xv) Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.

(xvi) Each sensor node shall be individually calibrated to NIST-traceable airflow standards at a minimum of 16 calibration points.

(xvii) The number of independent sensor nodes provided shall be as follows:

Duct or Plenum Area (sq. ft.)	Total Number of Sensors per Location
Less than 1.0	2
1.0 to 4.0	4
4.1 to 8.0	6
8.1 to 12.0	8
12.0 to 16.0	12
Greater than 16.0	16

A total of 4 probes shall be required for openings with an aspect ratio ≤ 1.5 and with an area ≥ 25 ft^2 (≥ 2.32 m^2).

i. Transmitter

(i) A remotely located microprocessor-based transmitter shall be provided for each measurement location.

(ii) The transmitter shall be comprised of a main circuit board and interchangeable interface card.

(iii) All printed circuit board interconnects, edge fingers, and test points shall be gold plated.

(iv) All printed circuit boards shall be Electroless Nickel Immersion Gold (ENIG) plated.

(v) All receptacle plug pins shall be gold plated.

(vi) The transmitter shall be capable of determining the average airflow rate and temperature of the sensor nodes.

(vii) Separate integration buffers shall be provided for display airflow output, airflow signal output (analog and network) and individual sensor output (IR-interface).

(viii) The transmitter shall be capable of providing a high and/or low airflow alarm.

(ix) The transmitter shall be capable of identifying an AMD malfunction via the system status alarm and ignore any sensor node that is in a fault condition.

(x) The transmitter shall be provided with a 16-character, alpha-numeric, LCD display.

(xi) The airflow rate, temperature, airflow alarm and system status alarm shall be visible on the display.

(xii) The transmitter shall be provided with two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals and select one or both of the following

(a) One isolated RS-485 (field selectable BACnet MS/TP or Modbus RTU) network connection; or

(b) One isolated Ethernet (simultaneously supported BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection.

(xiii) Analog output signals shall provide the total airflow rate and be field configurable to output one of the following:

(a) temperature

(b) airflow alarm

(c) system status alarm

(xiv) Network communications shall provide the average airflow rate, temperature, airflow alarm, system status alarm, individual sensor node airflow rates and individual sensor node temperatures.

(xv) The transmitter shall be capable of communicating with other devices using one of the following interface options:

(a) Linear analog output signals for airflow and temperature: Field selectable, fuse protected and electrically isolated from all other circuitry, 0-5VDC / 0-10VDC / 4-20mA (4-wire)

(b) RS-485: Field selectable BACnet-MS/TP or Modbus-RTU

(1) BACnet devices shall provide analog variables for airflow and temperature containing individual sensor airflow rate and temperature data.

(xvi) The transmitter shall be powered by 24 VAC and use a switching power supply that is over-current and over-voltage protected.

(xvii) The transmitter shall use a “watchdog” timer circuit to ensure continuous operation in the event of brown-out and/or power failure.

j. Performance

(i) Each sensing node shall have an airflow accuracy of ±2% of reading over an operating range of 0 to 5,000 FPM (25.4 m/s).

(ii) Accuracy shall include the combined uncertainty of the sensor nodes and transmitter.

(iii) Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with this requirement over the entire operating range.

(iv) Each sensing node shall have a temperature accuracy of ±0.15° F (0.1° C) over an operating range of -20° F to 160° F. (-28.9° C to 71° C).

(v) The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location either called for on the drawing or in this specification.

(vi) A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer's placement requirements.

(vii) After installation of measurement devices shall not be adjusted without approval in writing from the consulting mechanical engineer. If approval is given for adjustment, HVAC Contractor shall only make the adjustment with the assistance of an manufacturers authorized representative.

9. Space and Duct Carbon Dioxide Sensors

a. The sensor shall use non-dispersive infrared (NDIR) analyzers designed for measuring environmental CO2 concentration in ventilation systems and indoor spaces. The measurement range shall be 0-2000ppm.

b. Sensor accuracy shall be ±30 ppm ±2% of measured value with repeatability of ±20 ppm ±1% of measured value and a response time of <60 seconds for 90% step change.

c. The sensor shall have self-calibration algorithm with a calibration interval of 5 years.

d. Input power shall be 20 to 30 VDC/24VAC; 100mA maximum.

e. The output shall be 4-20mA/0-10V selectable with an available alarm relay for direct ventilation control.

f. The operating temperature range shall be32ºF to 122 ºF and the operating humidity range shall be 0 to 95% RH noncondensing.

g. Must comply with ASHRAE 62.1-2004 standard for air quality.

h. The sensor shall Veris CDE/CWE, or equal approved by engineer.

C. Binary Inputs

1. Differential Pressure Switch, Air

a. Diaphragm Material; Silicone

b. Housing; Zinc coated steel with NEMA 1 rating

c. Adjustable set point

d. Switch: Single pole; double throw (SPDT) (snap-action) pilot duty rated at 125VA. Enclosure connection cover

e. Port Sizing; ¼ inch barbed slip-on connection

f. Unit Mounting; Diaphragm in vertical position only

g. Provide sensing probe kit. Two probes required for differential pressure

h. Pressure Range; Suitable for equipment being monitored.

i. Furnish Cleveland Controls AFS-460 or equal as approved by engineer.

2. Freezestats

a. Furnish and install, for each air handling unit with outdoor air connections, a low temperature safety thermostat (freezestat) with a 20 ft. sensing element.

b. There shall be one freezestat per coil section.

c. Element shall be installed in a serpentine fashion across the inlet of the cooling coil in the air stream.

d. Element shall be arranged to stop the unit supply fan and its associated return air fan should the temperature at any point along the sensing element fall below 35ºF for an adjustable time period.

e. Low temperature detector shall be automatic reset, DPDT type.

f. Provide manual reset button at primary control panel and time delay relay to lockout fan if freeze condition exists for more than 60 seconds. Time delay relay shall be adjustable up to 5 minutes.

g. Furnish Honeywell L480G or equal as approved by engineer.

3. Current Sensing Relay

a. Provide and install current sensing relays for all motor where points list requires equipment status.

b. Sensor shall be split core, two wire, loop powered and sized for expected amperage. Unit shall be UL listed.

c. Provide status LEDs for current sensed below set point, current sensed above set point and loop power failure. The unit shall automatically range itself and have solid state outputs.

d. Furnish RIBXGTA by Functional Devices, Inc. or equal as approved by engineer.

4. Single Point Leak Detector

a. The leak detector shall provide a single point detection of leaks. The point detection sensor shall have two gold-plated sensing probes to prevent corrosion resistance and to provide accurate readings. Mounting brackets shall allow for sensor height adjustment and leveling.

b. The leak detector shall constantly monitor points for leaks, internal faults and power failures and warn of any abnormal conditions. The leak detector module shall indicate that water has contacted the sensors by actuating two output relays. The relays shall remain activated until the module is reset.

c. Provide Liebert LT-410 or engineer approved equal.

5. Zone Leak Detector

a. The alarm module shall indicate that water has contacted the sensors cable by actuating two output relays. The relays shall remain activated until the module is reset.

b. Provide Liebert LT -460 or equal.

6. Single Point Leak Detector

7. The Liqui-tect 410 (LT410) provides a single-point detection of leaks. The point detection sensor has two gold-plated sensing probes to prevent corrosion resistance and to provide accurate readings. The LT410 constantly monitors points for leaks, internal faults and power failures and warns of any abnormal conditions. Mounting rackets allow for sensor height adjustment and leveling.The LT410 is the ideal olution for sensing leaks under a raised computer floor or air conditioning drip pans. Two independent outputs provide added flexibility with the capacity to signal both a local alarm panel and a remote building management system or external equipment.

D. Miscellaneous Monitoring Systems

1. Commercial Energy Consumption Meter

a. The Energy Meter shall consist of digital electronic circuitry.

b. The Energy Meter shall conform to ANSI C12.1 metering accuracy standards.

c. The Energy Meter system shall consist of a meter and included CT(s) calibrated together as a system.

d. The Energy Meter's system accuracy shall be +/- 1% from 2 % to 100 % of the rated current over a temperature range of 32-122° F.

e. The Energy Meter shall require no annual recalibration by users in the field.

f. The Energy Meter shall derive operating power from its metering connections, and shall not require a separate control power connection.

g. The Energy Meter electronics shall automatically correct for CT phase reversal.

h. The Energy Meter CTs shall be factory assembled.

i. The Energy Meter shall have a backlit LCD display measuring 1.2" X 3.8" that is direct read without the need for multipliers.

j. The Energy Meter LCD display shall show accumulated kWh on the top half of the display while the bottom half of the display scrolls through Amps, Voltage, PF, KVAR, KVA, KW Real Power, as stated in point q below.

k. The Energy Meter shall meet UL and cUL specifications as listed in 3111-1.

l. The Energy Meter shall directly accept any voltage input from 120-480 VAC.

m. The Energy Meter shall be internally isolated to 2500 VAC.

n. The Energy Meter series shall have models available for amperage ranges of 100-2400 Amps.

o. The Energy Meter shall have a N.O. pulse output with selectable pulse output rates of 0.10, 0.25, 0.50, or 1.00 kWh per pulse.

p. The Energy Meter shall have a N.C. phase-loss alarm output operating at 100mA @ 24VAC/DC.

q. Using the optional Communications Board, the Energy Meter shall be networkable via an RS485 connection to a Modbus RTU network.

r. The information and capabilities provided by the Energy Meter shall include the following:

(i) Current, per phase & three-phase total

(ii) Voltage, per phase & three-phase total, phase-to-phase & phase-neutral

(iii) Real Power (kW), per phase & three-phase total

(iv) Reactive Power (kVAR), three phase total

(v) Apparent Power (kVA), three phase total

(vi) Power Factor, per-phase & three-phase total

(vii) Real Energy (kWh), three phase total

s. Furnish H8163 Series supplied by Veris Industries or equal as approved by engineer.

2. Water Leak Detection System

a. General

(i) Furnish and install a complete water detection system for each area specified. The system shall include electronic alarm and locating modules, sensing cable, graphic maps and all auxiliary equipment. The system shall simultaneously detect the presence of water at any point along the cable's length, sound an alarm, and pinpoint the distance to the leak. The sensing cable shall be of such construction that no metallic parts shall be exposed to the environment. The system shall provide pre-connecterized sensing cable and components. The system shall be UL listed and FM approved.

(ii) The water leak detection system shall be installed in the following areas: (Add locations for water leak detection system).

(iii) The system shall be as manufactured by Raychem Corporation or equal.

(iv) Provide two sets of test instrumentation to owner.

b. Locating leak detection panel (TTB-FA)

(i) The alarm and locator module, TTB-FA, shall monitor up to a maximum of 1000 feet of sensing cable. The alarm module shall indicate that water has contacted the sensing cable by sounding an audible alarm, actuating an output relay, sending a proportional 4-20 ma signal to the BMS and displaying the distance from the start of the sensing cable to the start of the first contact with water. The location of the first water contact shall be retained on the display until the cable is dry and the module is updated.

(ii) The alarm module shall be capable of detecting the presence of a 1 inch leak anywhere along the cable with a repeatability of +/- 1%.

(iii) The alarm module shall continuously monitor the sensing cables and interconnecting cables for continuity. Any break in the cable shall generate an audible alarm, activate an output relay and activate a "continuity" LED on the face of the module.

(iv) The alarm module shall have LED's indicating "power" (green), "alarm" (red) and "continuity" (yellow). The module shall be equipped with exposed test, reset and silence buttons. All other functions shall require key access.

(v) The alarm module shall be powered by emergency power.

(vi) The module enclosure shall be a minimum of 16 gauge steel, flush mounting type.

c. Single point leak detector

(i) The alarm module, TTC, shall monitor up to a maximum of 50 feet of sensing cable. The alarm module shall indicate that water has contacted the sensing cable by sounding an audible alarm and actuating an output relay. The relay shall remain activated until the cable is dry and the module is reset.

(ii) The alarm module shall be capable of detecting the presence of a 1 inch leak anywhere along the cable with a repeatability of +/- 1%.

(iii) The alarm module shall continuously monitor the sensing cables and interconnecting cables for continuity. Any break in the cable shall generate an audible alarm, activate an output relay and activate a "continuity" LED on the face of the module.

(iv) The alarm module shall have LED's indicating "power" (green), "alarm" (red) and "continuity" (yellow).

(v) The alarm module shall be powered by emergency power.

(vi) The module shall be mounted in a field equipment cabinet.

d. Water sensing cable

(i) The water sensing cable (TT-1000) shall detect the presence of water and pinpoint its location. The cable shall consist of four wires: Two sensor wires, a continuity wire and a return wire. All four wires shall be coated and insulated with a fluoropolymer and wound helically around a flouropolymer core. The cable shall have a breaking strength, including connectors, of at least 70 pounds, per ASTM D-638. The cable shall have an abrasion resistance of >65 cycles, per UL 719.

(ii) The sensing cable shall offer distributed sensing with the ability to detect the location of water at any point along the length of the cable. The cable shall be flexible, and carry less than 24VDC under normal conditions.

(iii) The system shall not alarm when in contact with any metallic equipment such as drip pans, floor tile supports, conduit, etc.

(iv) The cable shall be available in modular, pre-connectorized lengths of 5, 10, 15, 25 and 50 feet. Field splicing shall not be acceptable.

(v) The cable shall be UL 910 rated and plenum rated per NEC 725-2(b).

e. Jumper cable

(i) Jumper cable shall be used where leak detection cable is not required but continuity is required (in raceways between alarm module and floor surface, etc.). The jumper cable shall be plenum-rated and jacketed with fluoropolymer materials, as per NEC 725-2(b). The jumper cable shall consist of four different color (Y, B, R, G), insulated 18 AWG wires and shall be available in pre-connectorized lengths of 5, 10, 15, 25 and 50 feet.

f. Accessories

(i) Provide all end connectors, leader cables, hold down clips, caution tags, spray adhesive (3M 90M) as required.

g. Graphic display map

(i) Provide a graphic display map for each room served. The map shall be a 1/8 in = 1.0 ft scaled drawing of the area served, indicating actual equipment locations, floor tile and other points of reference. The actual cable routing shall be clearly marked on the map with actual scaled distances every 10 feet.

(ii) A dynamic graphic display, equivalent to the aforementioned map, shall be duplicated on the BMS operator workstation. The area in alarm (within 5 feet) shall blink in red until the alarm is cleared.

h. Performance

(i) A maximum wetted area of 2 inches of cable, at any point along the entire length of cable, shall activate an alarm.

(ii) The system shall be continuously monitored for continuity. The loss of continuity shall cause an alarm within 5 seconds.

(iii) The cable shall be capable of being cleaned with a clean dry cloth, in place.

(iv) The cable shall dry and reset the module immediately upon removal from free water. No shaking, wiping or mechanical action shall be required.

i. Installation

(i) All system components shall be installed in accordance with the manufacturer's recommendations. The manufacturer shall provide necessary installer training and supervision as required.

(ii) The cable shall be installed on clean, dry finished surfaces only (coordinate access and schedule installation as required) after the possibility of physical damage has been eliminated. The cable shall be fastened to the surface it is monitoring every 4 feet with hold down clips and spray mastic adhesive. Hold down clip installation shall be subject to spot checks during commissioning. If any clip fails, all other clips shall be re-attached and re-tested, at no additional cost.

(iii) The system shall be commissioned prior to acceptance. Submit a test procedure for approval.

j. Warranty

(i) All equipment shall be warranted to the same extent as the BMS system, or per the manufacturer's warranty, whichever is greater.

3. Audio/Visual Alarm Units

a. Provide one (1) audio/visual alarm unit(s) that shall be located if required.

b. Each audio/visual alarm unit shall include a 1" x 3" translucent illuminated rectangular alarm light ("BMS Alarm"), a Sonalert horn (hidden), a silence switch with stainless steel cover plate to match mounting surface. When any BMS alarm occurs (as coordinated with facilities personnel), the alarm light shall flash once per second (adjustable) and the horn shall sound. When the silence switch is pushed, the horn will silence and the pilot light shall light continuously until alarm is cleared.

c. The BMS shall monitor the alarm light, horn and silence switch status.

d. Provide 1/8 inch high engraved and painted lettering for operational instructions as required by the owner on the cover plate

2.6 OUTPUT DEVICES

A. General

1. All devices and equipment shall be approved for installation.

2. Provide the following field devices as required by the monitoring, control and optimization functions listed elsewhere in this specification.

B. Actuation

1. Electric

a. All damper actuation shall be electric. Pneumatic actuation is not acceptable.

2. Incremental Electronic Actuator for Terminal Equipment Damper Actuation

a. Incremental (floating) actuators shall be allowed for terminal equipment only.

b. Actuators shall be proportional, electronic, direct-coupled actuators used for modulating service. Actuators shall be equipped with metal housings and visual stroke indicators.

c. Actuators shall be equipped with a permanent manual adjustment.

d. Actuator shall fail-in-place.

e. Operating Voltage: 24 VAC.

f. Input Signal: 3 wire floating, 0 – 10 VDC, or 4 – 20 ma.

g. Spring Return Time: 20 seconds maximum.

h. For use when the maximum media temperature is 230° F.

i. Terminal Equipment includes

(i) Cabinet Unit Heaters

(ii) Fan Coil (AC) Units

(iii) Etc.

3. Damper Actuation

a. Damper actuators shall have external adjustable stops to limit the stroke in either direction.

b. All damper actuators shall have sufficient torque to overcome friction of damper linkage and air pressure acting on louvers and to operate the damper smoothly throughout the entire damper range.

c. Actuators shall be sized with a torque greater than 150% of the design damper torque.

d. Actuators shall have mounting arrangement for location outside of the air stream. The damper actuators shall be mounted on the damper extension so that it is not burned in the wall construction.

e. Damper actuators shall fail-safe in either the normally open or normally closed position in the event of power failure, signal failure or compressed air failure. Fail Safe Positions are as follows:

(i) Outside Air Dampers Normally Closed

(ii) Return Air Dampers Normally Opened

(iii) Exhaust Air Dampers Normally Closed

f. Provide one actuator per damper section. Where actuators do not have sufficient torque to operate damper section, either provide smaller damper sections to accommodate actuator torque or double torque master/slave damper actuators on the same shaft.

g. Electric Damper Actuation for Modulating and Two Position Dampers

(i) Proportional electronic, direct-coupled to either damper blade drive with no intermediate linkage or damper drive shaft; spring return

(ii) Actuator stroke by rotating motion (90º) of a reversible type synchronous motor with over load protection

(iii) Actuator shall be motor/drive in both the open and closed. (if spring return, drive to open and spring return closed).

(iv) Power input suitable for 120 Vac ±10 % or 24 Vac

(v) Proportional control damper actuators controlled from the BMS shall be designed to operate on a 4 to 20 mA or 0 to 10 Vdc and be compatible with either an analog or digital signal from the BMS

(vi) Two position control damper actuators controlled from the BMS shall be designed to operate on 24 Vac, 24 Vdc or 120 Vac single phase.

(vii) See Division 23; Section titled “Sequence of Operation for HVAC Controls for requirements for damper limit switches.

(viii) Operating Temperature Range; -40ºF to 140ºF

(ix) Actuator for terminal shall be in a plastic housing all other shall be in a die cast aluminum housing

(x) Actuator shall include permanent manual override, visual stroke indicators and built-in adjustable start and span controls

(xi) Manual drive release mechanism and manual positioning mechanism

(xii) Stroke time (full open to full closed)

(a) Two position damper; 60 to 90 seconds to drive open or closed 60 seconds spring return open or closed

(b) Proportional (modulating) Damper; 60 seconds to drive open, 15 seconds spring return closed)

(c) Smoke Control and Emergency Service; 15 to 30 seconds open or closed

2.7 DAMPER CONTRACTOR RESPONSIBILITY

A. Damper Responsibility Assignment

1. The following table summarizes the trade responsibilities with respect to automatic dampers (control):

	NON-FIRE OR SMOKE RELATED DAMPERS
Furnish Damper	Controls Contr.
Install Damper	Mech. Trade
Furnish Actuator(s)	Controls Contr.
Install Actuator(s)	Mech. Trade
Install and furnish terminal strip complete with all relays, wiring, etc.	Controls Contr.
Provide wiring between actuator, end switches, and terminal strip	Controls Contr.
Provide wiring from Central Control System (BMS) to damper terminal strip	Controls Contr.
Furnish 120V main power to elect. Actuators (See notes below)	Controls Contr.
Provide wiring from damper terminal strip to terminal strips for interlocked motors, etc.	Controls Contr.
Provide wiring from damper terminal strip directly to thermostats, etc.	Controls Contr.

NOTES

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

2. In electric closets 120V power circuits will be provided from an emergency appliance panel. These circuits will be terminated in a junction box located in each electric closet and shall be used by the controls contractor to supply local control panels and critical equipment.

3. For dampers not requiring control by the fire alarm system and for other non-critical equipment, obtain power from the motor starter control circuit. All wiring shall be by the controls contractor.

B. Damper Terminal Strips

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

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

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

a. Open Control - A pair of terminals shall be wired such that when a controls (BMS) relay closes a contact pair across these terminals the damper is driven open. If the damper is two position with an actuator which drives closed and springs open on loss of power then these terminals shall not be used. Where dampers are interlocked to motors then the wiring shall be to these terminals.

b. Close Control - A pair of terminals shall be wired such that when a controls (BMS) relay closes a contact pair across these terminals the damper is driven closed. If the damper is two position with an actuator which drives open and springs closed on loss of power then these terminals shall not be used.

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

C. Damper Responsibility Assignment

1. The following summarizes the trade responsibilities with respect to automatic dampers (control):

a. Damper for HVAC Control Controlled by Building Management System (BMS) only;

(i) Damper furnished by Contractor responsible for the Building Management/Temperature Control System

(ii) Actuator furnished by Contractor responsible for the Building Management/Temperature Control System

(iii) Damper and Actuator installed HVAC Contractor

(iv) Wiring of Actuator by Contractor responsible for the Building Management/Temperature Control System

2.8 AUTOMATIC CONTROL DAMPERS

A. Automatic Temperature Control/Building Management System Manufacturer/Contractor shall furnish all control dampers and actuators as part of the work of this section.

B. HVAC Contractor shall install control dampers and actuators.

C. General

1. See previous subparagraphs titled Damper Responsibility Assignment for delineation of work associated with dampers.

2. Individual damper sections shall be limited to a maximum of 20.0 square feet. For damper with areas greater than 20.0 square feet, provide multiple section with total area as required.

3. Multiple section dampers shall have an actuator for each damper section.

4. Two position dampers shall be either parallel blade or opposed blade

5. Modulating dampers shall be oppose blade

6. Actuator shall be furnished as part of the work of this section for each automatic control damper. Provide actuator mountings brackets, drive arms, linkages and appurtenances as required for proper mounting of actuator. Where possible, actuators shall be factory mounted by damper manufacturer

7. Size actuators in accordance with manufacturers recommendation and industry standard

8. Install all actuators with complete access for maintenance and replacement. Installation of actuator within airstream will only be permitted where duct configuration do not allow for installation outside of airstream and written approval.

9. All dampers shall be installed by the mechanical contractor.

10. The BMS contractor shall furnish damper actuators for all dampers that he furnishes. Where practical, actuators shall be factory mounted by the damper manufacturer. The controls contractor shall provide a terminal strip alongside the damper for all dampers he furnishes.

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

12. The controls contractor shall provide wiring as follows:

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

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

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

14. Dampers incorporating multiple sections shall be designed in such a way that the actuators are easily accessible. Under no circumstances shall it be necessary to remove damper sections or structural or other fixtures to facilitate removal of damper motors. Provide access doors wherever necessary to meet this requirement. In particular, ensure that where in-air stream actuators are provided, they are readily accessible.

15. The BMS contractor shall provide all power and control wiring for all automatic dampers as required to accomplish the HVAC control sequences of operation. A portion of this work may also be specified in other areas of the specification. It is the responsibility of the BMS contractor to coordinate this work with the other trades. Any work not performed by others will be the ultimate responsibility of the BMS contractor. The fire alarm system shall be able to open or close each damper, regardless of BMS commands.

D. Two position automatic control damper

1. Frame

    a. 5 inches x minimum 16 gage roll formed galvanized sheet hat-shape channel

    b. Reinforced at corners

    c. Frame design strength shall be structurally equivalent to 13 gage channel

    d. Flange 1 ½ inch rolled formed at part of frame.

    e. Flange location front, rear or front and rear as required by project requirements.

    f. Flange shall be T flange construction minimum 6 inches x 1 3/8 inches with bolted corners where project conditions have damper installed in “Duct-mate” type systems.

2. Blades

   a. Action; Parallel

   b. Style: Single skin with minimum 3 full length longitudinal grooves

   c. Material; 6 gage galvanized steel equivalent thickness

   d. Blade Width; Nominal 6 inches

   e. Blade Length; Blade length shall limited to deflection of less than 1/180 of blade span at system design static pressure but in no case greater than 60 inches.

   f. Blade Orientation; Horizontal. If because project conditions dictate. vertical blades with thrust washers

3. Bearings; Molded synthetic sleeve turning in extruded hole in frame

4. Blade Seals

   a. Material; Neoprene, vinyl, polyurethane, silicone rubber, synthetic elastomer or PVC coated fiberglass material per manufacturers standard construction to meet leakage rate listed below

   b. Mechanical locked to blade edge.

   c. Field replaceable design

   d. Adhesive or clip-on type blade seals not acceptable

   e. Temperature Operating Range; -25ºF to 180ºF

5. Jamb Seal

   a. Flexible stainless steel; compression type

   b. Blade end overlapping frame for jam seal not acceptable

   c. Adhesive or clip-on type Jamb seals not acceptable

   d. Temperature Operating Range; -25ºF to 180ºF

6. Axles; Minimum ½ inch diameter plated steel; hexagonal-shape mechanically attached to blades

7. Linkage; Concealed in frame. Linkage in air stream not permitted

8. Damper Position; Two position indicator switches linked directly to damper blades to remotely indicate damper position.

9. Performance Criteria

   a. Damper performance and ratings tested and certified in accordance with AMCA Publication 500 for maximum air flow and maximum pressure rating.

   b. Comply with the requirements of the AMCA Certified Rating Program

   c. Leakage; Not to exceed 8 CFM per sq. ft. @ 4 inches static pressure

   d. Pressure Drop; Maximum 0.07 inches w.g. @ 1,500 FPM across a 24 inch x 24 inch damper section

10. Multiple Damper Configuration; Where cross-section area of damper requires multiple damper section, HVAC Contractor shall provide reinforcement and bracing as required to hold against maximum system static pressures

E. Modulating Dampers

1. General; Damper shall be designed for linear flow (proportional) characteristics from closed to 100% open and 100% open to closed.

2. Frame Construction

   a. 5 x 1 inches x 0.125 minimum wall thickness extruded aluminum hat channel

   b. Hat mounting flanges on both sides of frame or "T" flange for installation in "Duct-mate" type systems as required by project requirements.

   c. Corners reinforced with two die formed internal braces

   d. Flange location front, rear or front and rear as required by project requirements.

3. Blade Design

   a. Action; Opposed

   b. Style: Airfoil shape

   c. Extruded aluminum with internal structural reinforcing tube running full length of blade

   d. Blade Width; Nominal 6 inches

   e. Blade Length; Blade length shall limited to deflection of less than 1/180 of blade span at system design static pressure but in no case greater than 60 inches.

   f. Blade Orientation; Horizontal. If project conditions dictate. vertical blades with thrust washers

   g. Maximum single section size 48 inches wide x 60 inches high

4. Bearings;Non-corrosive molded synthetic

5. Blade Edge Seals

   a. Extruded double edge design

   b. Inflatable pocket design to enable air pressure from either direction to assist in blade seal –off

   c. Seals mechanically locked into extruded blade slots

   d. Field replaceable design

   e. Adhesive or clip-on type blade seals not acceptable

6. Jamb Seal

   a. Flexible metal compressible type

7. Axles; Minimum ½ inch diameter plated steel; hexagonal-shape mechanically attached to blades Round axles not acceptable

8. Linkage; Concealed in frame. Linage in air stream not permitted

9. Performance Criteria;

   a. Damper performance and ratings tested and certified in accordance with AMCA Publication 500 for maximum air flow and maximum pressure rating.

   b. Comply with the requirements of the AMCA Certified Rating Program.

   c. Damper shall be tested and licensed in accordance with AMCA 511 for Air Performance and Air Leakage

   d. Damper shall be tested and licensed in accordance with ASHRAE RP1157 for linear flow.

   e. Temperature Rating: -22°F to 122°F

   f. Leakage; Not to exceed 8 CFM per sq. ft. @ 4 inches w.g. static pressure and a maximum 3 CFM per sq. ft. @1 inch w.g.

   g. Pressure Drop; Maximum 0.07 inches w.g. @ 1,500 FPM across a 24 inch x 24 inch damper section

10. Multiple Damper Configuration; Where cross-section area of damper requires multiple damper section, HVAC Contractor shall provide reinforcement and bracing as required to hold against maximum system static pressures

2.9 CONTROL PANELS

A. Field Equipment Cabinets

1. All DDC controllers, transformers, electric relays, static pressure sensors, velocity pressure sensors, manual override switches, etc., shall be mounted in an appropriate NEMA enclosure and factory wired to terminal strips. The enclosure shall be constructed of steel or extruded aluminum and shall be properly rated for the location. Securely mount the enclosures to the wall or floor of the building structure using approved bracing adjacent to each system to be controlled.

2. Cabinets shall allow extra space for installation of future control components.

3. Submit for approval all proposed locations of DDC control and accessory panels.

4. Submit for approval dimensioned shop drawings of the panel equipment layout prior to panel fabrication.

5. Properly label all panel components including wiring and tubing.

2.10 NON BMS DEVICES

A. Non-BMS Monitored Devices

1. Electric Thermostats

a. Furnish and install all electric thermostats for local control of miscellaneous equipment (unit heater, cabinet heater, baseboard heater, etc.) that use on/off control. Thermostat contacts shall be rated for maximum heater amperage and shall be snap acting, SPDT.

b. Space thermostat shall have:

(i) Concealed set point adjustment with a range of 55 -85 deg. F.

(ii) Concealed thermometer temperature indication

(iii) Heat-off-cool switch (if applicable)

(iv) Fan speed switch (2 or 3) (if applicable)

c. Voltage; Line voltage for equipment rated at 120 volts or for equipment rated at greater than 120 volts, coordinate with approved equipment for transformed voltage.

PART 3 - EXECUTION

3.1 DESIGN CRITERIA

A. The Building Management System (BMS) shall be programmed to start and stop the HVAC equipment based on occupancy schedules as coordinated with the owner. The BMS shall also provide equipment interlocks as required.

B. Each preheat coil section shall be provided with a separate sensor, control loop, output signal, and freezestat.

C. All control dampers that are sequenced shall be provided with dedicated analog outputs or positioning relays, as applicable.

D. Fire Alarm Interface for Fans

1. The Fire Alarm System shall provide outputs to notify the BMS of fire alarms.

2. All fan systems shall be stopped from the FAS. When the fan system stops, all associated dampers shall close.

3. All return and exhaust fans shall be stopped from the FAS. When the fan stops, all associated dampers shall close.

E. All safeties shall be capable of being remotely reset from the BMS.

F. All setpoints shall be adjustable from any BMS personal computer operator workstation via single point commands.

G. All reset schedule parameters shall be adjustable from any BMS personal computer operator workstation via single point commands.

H. All inputs and outputs shall be provided with programmable (adjustable) high and low software alarm limits.

3.2 INSTALLATION CRITERIA

A. Space mounted devices are to be identical in appearance. All devices shall be mounted under the same style cover.

B. Room sensors and thermostats shall not be located on outside walls.

C. Provide all relays, switches, sources of electricity and all other auxiliaries, accessories and connections necessary to make a complete operable system in accordance with the sequences specified.

D. Install controls so that adjustments and calibrations can be readily made. Controls are to be installed by the control equipment manufacturer.

E. Mount surface-mounted control devices, tubing and raceways on brackets to clear the final finished surface on insulation.

F. Conceal control conduit and wiring in all spaces except in the Mechanical Equipment Rooms and in unfinished spaces. Install in parallel banks with all changes in directions made at 90 degree angles.

G. Unless otherwise noted, install wall-mounted sensors, thermostats and humidistats to meet American Disability Act (ADA), Fair Housing Act (FHA) or other local, State or Federal having jurisdiction requirements. Submit device samples, locations, mounting heights and details for approval for all devices.

H. Install outdoor thermostats in perforated tube and sun shield.

I. All relays, electrical wiring, panels, outputs, etc. to make a complete operational system, shall be provided and installed by this section. See sequences of operation for details.

J. Component Tags

1. All sensors shall be identified with 1"x 3" black labels with white lettering. Lettering shall be 1/4" high. Provide sensor number, HVAC Unit number, part number and sensor range on tag. Submit tag schedule and sample for approval.

2. All panels, auxiliary component panels, transformer panels, etc. provided by this contractor, shall be identified with 2"x 5" black lamacoid labels with engraved white lettering. Lettering shall be ½" high. Provide panel number, HVAC unit number and service on tag. Submit tag schedule and sample for approval.

3.3 ELECTRICAL WIRING

A. The BMS Contractor shall be responsible for all electrical control work associated with the BMS, HVAC and plumbing systems which is not specified as work of others.

1. Perform all wiring in accordance with all local and national codes including the NEC.

2. Install all line voltage wiring, concealed or exposed, in conduit in accordance with the Division 26 specifications, NEC and local building code.

3. All low voltage electrical control wiring and all Primary Network wiring throughout the building shall be run in conduit. Terminal equipment sensors and the secondary network wiring may be run in plenum rated cable above accessible hung ceilings. Plenum cable shall be run parallel to building lines and supported from the building structure (not from duct, pipe or associated hangers) with bridle rings.

4. Provide extension of 120 volt, 20 amp circuits and circuit breakers from emergency power panels and or electrical junction boxes for entire system, except terminal equipment, as required.

5. Surge transient protection shall be incorporated in the design of system to protect electrical components in all DDC control panels and operator workstations.

6. Provide all miscellaneous field device mounting and interconnecting control wiring for all mechanical systems including but not limited to the fuel oil system, emergency generators, AC units, condensing units, PIMs, ECMs, unit heaters, electric heaters, cabinet heaters, domestic water system, and plumbing systems.

7. All systems requiring interconnecting control wiring as specified herein, shall have hardwired interlocks and shall not rely on the BMS to operate. Interconnecting wiring shall be run in conduits separate from the BMS associated wiring.

8. All wiring for network communication, sensor signals and interlock wiring shall be permanently labeled at a minimum of 10-foot intervals. Label shall indicate BMS manufacturer's name and cable usage. Labels shall be securely fastened and not be damaged during installation. Cable jackets shall also be color coded to indicate application.

9. Cables shall be tagged or labeled at each termination point and in each intermediate junction box, pull box or cabinet through which they pass.

10. All control and power wiring associated with the control of all automatic dampers shall be installed in conduit, regardless of voltage. All control and power wiring for relays associated with the control of any automatic damper shall be installed in conduit, regardless of voltage.

11. Data communication between separate buildings or facilities shall be via fiber optic cable only.

12. Provide all line and low voltage wiring for the control of all HVAC motors (whether individual or as part of packaged equipment) and dampers, including wiring for EP's, PE's, relays, control panels, unit heater and cabinet heater control, etc., except as noted below.

    a. A separate system of wiring, for smoke and fire control of motors which are to be automatically and/or manually controlled by the fire protective alarm (FPA) system will be run to the motor starters or SCU enclosures by the electrical trade.

13. The BMS contractor shall provide wiring:

    a. Between thermostats, aquastats and unit heater motors.

    b. All control and alarm wiring for all control and alarm devices for all Sections of Specifications.

    c. 120 volt, single phase, 60 hertz emergency power to every BMS panel, , BMS console, PIM, CRT, CPU, , annunciator modules, modems, intercom modules, printers and to other devices as required. It is the intent that the entire building management system and all peripheral devices, alarms, etc., shall be operative under emergency power conditions in the building. The power supplies are to be extended in conduit and wire from emergency circuit breakers.

    d. Provide power supply wiring (as required) to all dampers which do not require "direct" (i.e., not in response to motor operation) smoke and fire control by the fire protective alarm (FPA) system.

e. Provide status function conduit and wiring for equipment covered under this section.

f. Provide conduit and wiring between the BMS panels and the temperature, humidity, or pressure sensing elements, including low voltage control wiring.

g. Provide conduit and control wiring for devices specified in this Section.

h. Provide conduit and signal wiring between motor starters in motor control centers and high and/or low temperature relay contacts and remote relays in BMS panels located in the vicinity of motor control centers.

i. Provide conduit and wiring between the PC workstation, electrical panels, metering instrumentation, indicating devices, miscellaneous alarm points, remotely operated contractors, and BMS panels, as shown on the drawings or as specified.

j. Provide electrical wall box and conduit sleeve for all wall mounted devices.

k. Where conduit is required, it shall be steel electric metallic tubing (EMT), except that it shall be galvanized intermediate steel conduit where located within 8'-0" of the floor in mechanical spaces (or is otherwise exposed to mechanical damage), or is intended for embodiment in concrete.

14. Wires and cables shall have characteristics - in compliance with Articles 725 and/or 800 (as applicable) of the National Electrical Code - as described elsewhere in the specifications or drawings for this project and shall be UL listed in accordance therewith.

15. Where wires and cables are permitted to be run without conduit, they shall be independently supported from the building structure or ceiling suspension systems at intervals not exceeding four feet on center, utilizing cable supports specifically approved for the purpose. Wires and cables shall not rest on or depend on support from suspended ceiling media (tiles, lath, plaster, as well as splines, runners or bars in the plane of the ceiling), nor shall they be supported from pipes, ducts or conduits. Where cables are bundled together, separate bundles shall be provided separately for each type of cabling and separately for each independent system. Bundling and/or supporting ties shall be of a type suitable for use in a ceiling air handling plenum regardless of whether or not installed in a plenum.

16. Utilize #14 A.W.G. THWN conductors minimum throughout for power wiring (120 VAC or greater) except in conjunction with a manual starter. For a manual starter, utilize conductors equal in size to those in the power circuit.

17. Motor control circuit wires may be run in the same conduit as the wires of motor power circuits; however, abide by the following:

a. Exclude motor control wires from enclosures (other than motor starter enclosures) which contain power circuit overcurrent protection and switching devices;

b. Exclude motor control wires from pull boxes and junction boxes containing the wires of main and submain feeders.

c. Utilize auxiliary pull boxes to separate motor control wires from motor power circuit wires at a point before the power circuit wires enter the items from which motor control wires are excluded.

d. Exclude motor control wires from the same conduits as motor power circuit wires larger than 250 MCM.

18. Examine raceways and building finishes to receive wires and cables for compliance with installation tolerances and other conditions. Do not proceed with installation until unsatisfactory conditions have been corrected.

19. Utilize copper conductors with THWN, THHN or XHHW insulation. Type THHW and THHW-2 shall not be utilized where excluded by conduit sizing. Type THWN shall not be utilized for connection to 100% rated overcurrent devices.

20. Pull conductors into raceway simultaneously where more than one is being installed in same raceway.

21. Use pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation.

22. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

23. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

24. Properly ground all field equipment panels and terminal unit equipment.

3.4 COORDINATION

A. Coordination with Other Trades

1. Piping and duct installation requirements are specified in other Division 23 Sections. Coordinate installation of all devices furnished under this section to be installed by other trades with the appropriate trade.

2. It is the responsibility of this contractor to coordinate with all trades the location of installed equipment and routing of all electrical control conduits and lines.

3. Install control system components to allow for proper service and maintenance of equipment.

B. Work Performance Schedule

1. A time-phased schedule for delivery, installation, and acceptance of components for the complete system shall be prepared. Submit this schedule to the Owner within five (5) days after award of contract. Submit updates and changes to this schedule promptly to the Owner.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

B. Commissioning, Testing and Acceptance

1. Perform a three-phase commissioning procedure consisting of field I/O calibration and commissioning, system commissioning and integrated system program commissioning. Document all commissioning information on commissioning data sheets that shall be submitted prior to acceptance testing. Commissioning work that requires shutdown of system or deviation from normal function shall be performed when the operation of the system is not required. The commissioning must be coordinated with the owner and construction manager to ensure systems are available when needed. Notify the operating personal in writing of the testing schedule so that authorized personnel from the owner and construction manager are present throughout the commissioning procedure.

2. Phase I – Field I/O Calibration and Commissioning

a. Verify that each control panel has been installed according to plans, specifications and approved shop drawings. Calibrate, test, and have signed off each control sensor and device. Commissioning to include, but not be limited to:

(i) Sensor accuracy at 10, 50 and 90% of range.

(ii) Sensor range.

(iii) Verify analog limit and binary alarm reporting.

(iv) Point value reporting.

(v) Binary alarm and switch settings.

(vi) Fail safe operation on loss of control signal, electric power, network communications, etc.

3. Phase II – System Commissioning

a. Each BMS program shall be put on line and commissioned. The contractor shall, in the presence of the owner and construction manager, demonstrate each programmed sequence of operation and compare the results in writing. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracy. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between the specification and the actual performance will be immediately rectified and re-tested.

4. Phase III - Integrated System Program Commissioning

a. Tests shall include, but not be limited to:

(i) Data communication, both normal and failure modes.

(ii) Fully loaded system response time.

(iii) Impact of component failures on system performance and system operation.

(iv) Time/Date changes.

(v) End of month/ end of year operation.

(vi) Season changeover.

(vii) Global application programs and point sharing.

(viii) System backup and reloading.

(ix) System status displays.

(x) Diagnostic functions.

(xi) Power failure routines.

(xii) Battery backup.

(xiii) Smoke Control in concert with Fire Alarm System testing.

(xiv) Testing of all electrical and HVAC systems with other division of work.

b. Test procedure and documentation shall be as follows:

(i) Submit for approval, a detailed acceptance test procedure designed to demonstrate compliance with contractual requirements. This Acceptance test procedure will take place after the commissioning procedure but before final acceptance, to verify that sensors and control devices maintain specified accuracy and the system performance does not degrade over time.

(ii) Using the commissioning test data sheets, the contractor shall demonstrate each point. The contractor shall also demonstrate 100 percent of the system functions. The contractor shall demonstrate all points and system functions until all devices and functions meet specification.

(iii) The BMS contractor shall supply all instruments for testing. Instruments shall be turned over to the owner after acceptance testing.

(iv) All test instruments shall be submitted for approval prior to their use in commissioning.

(v) Test Instrument Accuracy:

(a) Temperature: 1/4F or 1/2% full scale, whichever is less.

(b) High Pressure (PSI): ½ PSI or 1/2% full scale, whichever is less.

(c) Low Pressure: 1/2% of full scale (in w.c.)

(d) Humidity: 2% RH

(e) Electrical: 1/4% full scale

(vi) After the above tests are complete and the system is demonstrated to be functioning as specified, a thirty-day performance test period shall begin. If the system performs as specified throughout the test period, requiring only routine maintenance, the system shall be accepted. If the system fails during the test, and cannot be fully corrected within eight hours, the owner may request that performance tests be repeated.

c. Sub Systems shall also be tested and commissioned.

5. Move In Checkout

a. Each floor shall be re-tested 24 hours prior to move in. The test shall ensure all corrective work is complete and all systems are 100% operational.

6. Additional testing, debugging and fine tuning

a. Provide an additional 100 overtime hours of appropriate highest labor cost category to be used at the owner's discretion to test, debug and fine tune the system after occupancy.

C. Owner System Performance Verification (OSPV) (If required)

1. The systems and equipment shall be fully functional and operational prior to the OSPV process, or the contract(s) will be back-charged accordingly.

2. OSPV is the process in which the contractor fully demonstrates system operation, system performance, proper operation of the sequence of operations, and system equipment to the Owner’s operating staff in the presence of an OSPV agent.

3. After the contractor’s obligations are completed, including system testing, equipment testing, calibration, system demonstration, sequence of operation start-up, training, providing of maintenance and operation manuals, and corrective action for all punchlist items, the OSPV process begins. The BMS Contractor shall include in their bid the number of hours and the number of technicians required for the OSPV process but in no case less than 80 hours and two technicians.

4. Complementary to the BMS contractor's responsibility to commission the building systems, an OSPV agent will be retained by the Owner. This OSPV agent will provide independent equipment-systems installation inspection and performance verification. The independent verification will be requested prior to final equipment and systems acceptance by the Owner. It should be emphasized that independent systems verification prior to the OSPV process does not negate the BMS contractor's obligations to full commission the control system.

5. The OSPV agent will verify system installation, operation, performance, and sequences of operation after the BMS contractor provides written notice that the building system is completed, tested, and fully operational. Upon this notification, the OSPV agent will perform the initial verification. The OSPV agent will provide one (1) additional installation and performance verification, upon notification by the BMS contractor that deficiencies identified have been corrected. Any subsequent installation and performance verification will be at the BMS contractor's expense.

6. All building systems shall be verified under actual and simulated full load conditions.

7. The Owner, Architect, Engineer, and OSPV agent will have input to and be part of the approval process for systems performance verification.

8. The Owner's staff shall be informed of all system start-up, shutdown, and verification procedures that involve any utility usage or interruption.

9. The BMS contractor's technicians provided for the OSPV process shall be thoroughly familiar with the OSPV process (start-up, sequence of operation, shutdown, etc.) and the system or equipment required for the OSPV work. The personnel must also be thoroughly familiar with the project specifications and drawings. Convenient technician substitutes for the OSPV process are unacceptable.

10. Under OSPV, the following shall be verified:

    a. Point to point verification of all BMS points.

    b. The sequence of operation for all systems and equipment.

    c. Calibration of all inputs and outputs.

    d. Operation of the compressed air plant.

    e. System programming.

    f. Standard operation procedures (SOP).

11. The OSPV process includes but is not limited to the above items.

3.6 DEMONSTRATION

A. Maintenance Data and Operating Instructions

1. Description - Maintenance and operating manuals in accordance with Division 01; titled "General Requirements".

    a. Prepare data in the form of an instructional manual.

2. Manual for Equipment and Systems

    a. Each item of equipment and each system: Include description of unit or system, and component parts. Identify function, normal operating characteristics, and limiting conditions. Include performance curves, with engineering data and test, and complete nomenclature and model number of replaceable parts.

    b. Panelboard Circuit Directories: provide electrical service characteristics, controls, and communications.

    c. Include wiring diagrams as installed.

    d. Operating Procedures: Includes start-up, break-in and routine normal operating instructions and sequences. Include regulation, control stopping, shutdown and emergency instructions. Include summer, winter, and any other special operating instructions.

    e. Maintenance Requirements: Include routine procedures and guide for preventative maintenance, trouble shooting; disassembly repair, re-assembly instructions including alignment, adjusting, balancing, and checking instructions.

    f. Provide servicing and lubrication schedule for dampers and actuators. Provide a list of lubricants required.

    g. Include manufacturers printed operation and maintenance instructions.

    h. Include sequence of operation by controls manufacturer.

    i. Provide original manufacturer's parts list, illustrations, assembly drawings, and diagrams.

    j. Provide control diagrams by controls manufacturer as installed.

    k. Provide contractor's coordination drawings with control piping diagrams as installed.

    l. Provide list of original manufacturer's spare parts. Provide a recommendation of quantities to be maintained in storage.

    m. Provide additional requirements as specified in individual product specification sections.

3. Instruction of Facility Personnel

a. Before final inspection, instruct Owner's designated personnel in operation, adjustment and maintenance of products, equipment, and systems, at agreed upon times.

b. For equipment requiring seasonal operation, perform instruction for other seasons within six months.

c. Use operation and maintenance manuals as basis for instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.

d. Prepare and insert additional data in Operation and Maintenance manual when need for such data becomes apparent during instruction.

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

B. Display of Maintenance Instructions

1. One set of operating and maintenance instructions shall be neatly framed behind glass and hung adjacent to the equipment concerned.

C. Training

1. The Contractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 8:00 a.m. to 4:30 p.m. weekdays.

2. Provide eighty (80) hours of training for Owner's operating and maintenance personnel. 40 hours shall be off site classroom training and 40 hours shall be on-site training. Videotape all sessions and edit each session to 1-hour tapes. Turn over two copies each unedited and edited tape to the Owner. Training shall include:

a. Explanation of drawings, operator's and maintenance manuals.

b. Walk-through of the job to locate all control components.

c. Operator workstation and peripherals.

d. DDC Controller and ASC operation/function.

e. Operator control functions including graphic generation, if design includes color graphics, and field panel programming.

f. Operation of portable operator's terminal, if an operator terminal is provided to the owner as per this specification.

g. Explanation of adjustment, calibration and replacement procedures.

3. Provide 8 hours of additional training quarterly during warranty period.

4. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the Owner requires such training, it will be contracted at a later date. Provide description of available local and factory customer training. Provide costs associated with performing training at an off-site classroom facility and detail what is included in the manufacturer's standard pricing such as transportation, meals, etc.

3.7 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested by the Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

END OF SECTION 23 09 00

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SECTION 23 09 10 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems, and equipment.

B. All set points referenced in this section are subject to change and shall be adjustable from the BMS Operator Workstation and from a Portable Operators Terminal.

C. Related Sections include the following:

1. Division 23 Section "HVAC Instrumentation and Controls" for control equipment and devices and submittal requirements.

2. Applicable Sections of Division 23 for equipment provided with factory mounted controls that interface with the Building Management System (BMS) provided as part of this Section.

3. Applicable Sections of Division 21, 22 & 26 for equipment provided with factory mounted controls that interface with the Building Management System (BMS) provided as part of this Section

1.3 DEFINITIONS

A. AI - Analog Input

B. ANSI - American National Standards Institute

C. AO - Analog Output

D. ASCII - American Standard Code for Information Interchange

E. AWG - American Wire Gauge

F. BMS - Building Management System

G. CPU - Central Processing Unit

H. CRT - Cathode Ray Tube

I. DAC - Digital to Analog Converter

J. DDC - Direct Digital Control

K. DI - Digital Input

L.	DO	-	Digital Output
M.	EEPROM	-	Electronically Erasable Programmable Read Only Memory
N.	EMI	-	Electromagnetic Interference
O.	FAS	-	Fire Alarm Detection and Annunciation System
P.	HOA	-	Hand-Off-Auto
Q.	IEEE	-	Institute of Electrical and Electronics Engineers
R.	I/O	-	Input/Output
S.	LAN	-	Local Area Network
T.	LCD	-	Liquid Crystal Display
U.	LED	-	Light Emitting Diode
V.	MCC	-	Motor Control Center
W.	NC	-	Normally Closed
X.	NO	-	Normally Open
Y.	OWS	-	Operator Workstation
Z.	OAT	-	Outdoor Air Temperature
AA.	PC	-	Personal Computer
BB.	RAM	-	Random Access Memory
CC.	RFI	-	Radio Frequency Interference
DD.	RH	-	Relative Humidity
EE.	ROM	-	Read Only Memory
FF.	RTD	-	Resistance Temperature Detector
GG.	TCP/IP	-	Transmission Control Protocol/Internet Protocol
HH.	UPS	-	Uninterruptible Power Supply
II.	VAC	-	Volts, Alternating Current
JJ.	VDC	-	Volts, Direct Current
KK.	WAN	-	Wide Area Network .

1.4 BMS INTERFACE TO PACKAGED ROOFTOP AIR HANDLING UNITS (899-DOAS-R-01 & 899-DOAS-R-02)

A. General:

1. Service:

a. The DOAS unit shall be controlled by a DDC controller furnished, installed, and wired by the air handling unit manufacturer.

b. The BMS Contractor shall furnish a software interface to the air handling unit controller which shall monitor and control the points outlined on the input/output point summary, as shown on drawing M-705.

c. The BMS contractor shall furnish, install, and wire all devices necessary for complete operation of the air handling unit including space thermostats, etc.. The BMS contractor shall furnish, install, and wire the communications bus for the AC DDC controllers.

d. The BMS contractor shall furnish, install, and wire all devices needed in addition to those specified to control the air handling unit for setback and setup operation during unoccupied mode as well as warm-up and cool-down modes.

2. System Off:

a. Supply and Exhaust Fan: Off.

b. Outside Air Damper: Closed.

c. DX Cooling: Off.

d. Electric Heat: Off - SCR to 0%.

3. System Start:

a. The air-handling unit shall be started based upon a start time optimization program, time of day schedule, or manual command.

b. When the air-handling unit is indexed to operate, all dampers shall open. Where required, hard-wired damper end switches shall prove damper status prior to fan start.

c. The exhaust fan shall start first. Following a 5-second delay, the supply fan shall start.

4. System Run:

a. Occupied Mode:

(i) Supply and Exhaust Fan: Supply and Exhaust fan shall run continuously.

(ii) DX Cooling: Modulate in sequence with hot gas bypass to maintain the discharge air temperature at setpoint as reset by space temperature.

(iii) Electric Heat: Modulate SCR in sequence with the DX cooling to maintain the discharge air temperature setpoint when the supply fan is on.

(iv) Operate at a 50% setback during unoccupied periods in conjunction with exhaust fans

5. System Stop:

a. When the air-handling unit is indexed to shut down, the supply and exhaust fan shall stop.

b. Dampers and electric heat shall be indexed to their 'System Off' conditions.

6. Safeties And Alarms:

a. Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

b. High Static: High discharge pressure switches shall stop the supply and exhaust fans when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their 'System Off' conditions. The fans shall remain off until the pressure switch is manually reset.

c. Filter Condition: Monitor differential pressures across filter and annunciate alarm when differential pressure set point is exceeded.

d. Emergency Shutdown:

(i) Duct smoke detector(s) shall stop the supply and exhaust fans and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detectors shall be wired into the building fire alarm system.

(ii) The supply and exhaust fans shall be interlocked to shut down upon a command from the building fire alarm system.

e. Annunciate off alarms whenever supply or exhaust fan status does not equal start command.

7. Failure Modes:

a. Fan Failure: If the supply or exhaust fan fails to operate, both fans shall shut down and alarm shall be annunciated. Dampers shall be indexed to their 'System Off' conditions.

b. Sensor Failure: Upon the failure of an analog sensor, associated dampers and control valves shall remain at their last position and alarm shall be annunciated.

c. Power Failure:

(i) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(ii) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

8. Unoccupied mode:

a. During unoccupied hours, only one (1) of the two (2) DOAS units will operate in a lead/lag fashion to reduced runtime on the units. This sequence will allow partial ventilation of spaces during unoccupied hours.

b. During this sequence, the supply duct's normally closed automated damper that joins the two DOAS systems will be commanded open to allow air from one (1) DOAS to service both ducted system areas.

1.5 VRF AC Unit

A. Service:

1. Indoor Evaporator Units: 899-CU-R-01 THROUGH 899-CU-R-05

2. Air-Cooled Condensing Unit: 899-AC-1-01A THROUGH 899-AC-1-01G, 899-AC-1-02A THROUGH 899-AC-1-02G, 899-AC-1-03A THROUGH 899-AC-1-03E, 899-AC-1-04A THROUGH 899-AC-1-04G, 899-AC-1-05A THROUGH 899-AC-1-05F

B. The air conditioning units shall be furnished with local controls for stand-alone operation.

C. The BMS Contractor shall provide all required field wiring of controls that cannot be factory installed for proper AC unit operation including space thermostats, communication bus, heat recovery box, branch circuit box and remote condensing unit interlock wiring.

D. The BMS contractor shall furnish a BACnet serial interface to connect the AC unit master control module to the BMS. The AC unit manufacturer shall provide a master control module communication card. The BMS contractor shall provide an interface and all programming to monitor and control all points from the AC units to the BMS.

E. For ceiling mounted units, the BMS contractor shall furnish and install a leak detector that shall be located in the unit's drip pan. The BMS shall also monitor the condensate pump high level float switch and when water is detected in the pan of the high level float switch closes, the AC shall shut down and an alarm shall be annunciated to the BMS. The unit shall remain off until the high-water condition has been corrected.

F. Coordinate control of electric mats through the BMS per drawing M-705. Electric mats to be controlled by the BMS, while VRF units to be controlled by VRF thermostats with override at BMS. BMS to ensure that there is no simultaneous heating and cooling. Refer to drawing M-150 for sensor locations.

G. Fan speed is adjustable and a control point on drawing M-705. Fan to run in auto speed for optimum operation of the unit. Fan to run continuously during occupied hours to ensure ventilation and air changes to the space.

H. DDC Points:

1. All AC Unit Points via BACnet Network Interface as noted on drawing M-705.

2. Condensate High Level/Drip Pan Water Leak Detection Alarm

I. VRF AC Unit Serving Electrical Room and TELE/DATA room

1. Service:

a. Indoor Evaporator Units: 899-AC-1-06, 899-AC-1-06,

b. Air-Cooled Condensing Unit: 899-CU-1-06, 899-CU-1-07,

2. The air conditioning units shall be furnished with local controls for stand-alone operation.

3. The BMS Contractor shall provide all required field wiring of controls that cannot be factory installed for proper AC unit operation including space thermostats, communication bus, and remote condensing unit interlock wiring.

4. The BMS contractor shall furnish a BACnet serial interface to connect the AC unit master control module to the BMS. The AC unit manufacturer shall provide a master control module communication card. The BMS contractor shall provide an interface and all programming to monitor and control all points from the AC units to the BMS.

5. The BMS shall monitor the condensate pump high level float switch and when water is detected, the AC shall shut down and an alarm shall be annunciated to the BMS. The unit shall remain off until the high-water condition has been corrected.

6. For the Tele/data room and Electrical Room provide an independent temperature sensor to monitor the space temperature and annunciate an alarm to the BMS if the high alarm limit temperature is reached.

7. DDC Points:

a. All AC Unit Points via BACnet Network Interface per drawings M-704 and M-705

b. Condensate High Level/Drip Pan Water Leak Detection Alarm

c. Space Temperature w/ High/Low Alarm

1.6 ELECTRIC RADIANT MATS

A. Refer to drawings M-150, M-502, M-705 and coordinate with electrical drawings. The BMS Contractor shall provide all required field wiring of controls.

B. Electric mats to maintain a set floor temperature through the BMS based upon a time of day schedule.

C. Operation of electric mats to be locked out by the BMS when the room AC unit(s) is(are) in cooling.

D. Combination space temperature and CO2 sensor is tied into BMS DDC panel. Radiant floor heat is enabled/disabled via BMS based on outside air temperature below 55 deg_F (adjustable). When enabled, the radiant floor heat sensor shall maintain floor temperature at setpoint, 85 deg_F (adjustable), via manufacturer furnished temperature sensor(s).

1.7 GENERAL EXHAUST FAN LESS THAN 2000 CFM: 899-TXF-R-01, 899-TXF-R-02, 899-GXF-R-01

A. General:

1. Service: See mechanical equipment schedule.

B. System Off:

1. Exhaust Fan: Off.

2. Damper: Fully closed.

C. System Start:

1. Exhaust Fan: The fan shall be started through the BMS based upon a start time optimization program, time of day schedule, or manual command.

2. Damper: When the fan is indexed to operate, all exhaust air dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

D. System Run:

1. Exhaust Fan: Fan shall run continuously.

2. Damper: Remain full open.

E. System Stop:

1. Exhaust Fan: When the fan is indexed to shut down, the exhaust fan shall stop.

2. Damper: Dampers shall be indexed to their 'System Off' conditions.

F. Safeties And Alarms:

1. Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

G. Failure Modes:

1. Fan Failure: If the exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their 'System Off' conditions.

2. Power Failure:

   a. Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

   b. Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

3. Dampers: Exhaust dampers shall be provided with spring return actuators to fail to their 'System Off' positions.

1.8 EXHAUST FAN WITH SPACE TEMPERATURE CONTROL: 899-TF-1-01, 899-TF-1-02, 899-TF-1-03

A. General:

1. Service: See mechanical equipment schedule.

B. System Off:

1. Exhaust Fan: Off.

C. System Start:

1. Exhaust Fan: The fan shall be started whenever the space temperature rises above the space temperature setpoint of 80EF.

D. System Run:

1. Exhaust Fan: Fan shall run based on the space temperature sensor.

E. System Stop:

1. Exhaust Fan: When the temperature is at or below setpoint the fan shall stop.

F. Failure Modes:

1. Fan Failure: If the exhaust fan fails to operate an alarm shall be annunciated at the BMS.

2. Power Failure:

   a. Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

   b. Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

1.9 MISCELLANEOUS SYSTEM CONTROL SEQUENCES

A. Electric Unit Heater: 899-EH-1-01, 899-EH-1-02

1. Electric Unit Heater Monitored by BMS

a. Alarm

(i) An alarm shall be annunciated on the BMS if the space temperature exceeds the high or low alarm limits.

b. A factory furnished thermostat on the unit shall control the temperature setpoint. The BMS contractor shall furnish, install, and wire a space temperature sensor to monitor space temperature. On a fall in space temperature an alarm shall be annunciated at the BMS.

c. The space temperature sensor and fan status shall be a BMS input. Fan status shall be monitored via a current sensing relay.

B. Equipment Restart Program

1. Subsequent to any building wide equipment shutdown, due to power failure, occupancy scheduling, priority lead shedding, etc., the mechanical equipment (with the exclusion of those supplied with emergency power) restarts shall be staggered and phased to minimize peak electrical loads. Time delays shall be adjustable and shall be provided for each controlled motor. The final restart sequence shall be submitted for approval.

2. All units shall be remotely reset and restarted from the BMS after a safety shutdown.

C. Air Filter (At all locations)

1. The BMS system shall monitor the actual differential pressure across each filter. An alarm shall be generated if the differential pressure exceeds design conditions.

D. Heat Trace

1. The BMS shall monitor a common alarm contact from each heat trace control panel.

2. The BMS shall override the heat trace system on and sound an alarm if outside air temperature falls below 40°F and the heat trace system has not activated.

E. Domestic Hot Water Heaters

1. The BMS contractor shall install and wire all devices supplied by the domestic hot water heater manufacturer. The BMS contractor shall furnish, install, and wire any devices not furnished by the domestic hot water heater manufacturer that are necessary for a completely operational domestic hot water heating system

2. The BMS shall monitor common alarm and supply water temperature. If an abnormal condition exists, an alarm shall sound at the BMS

F. Automatic Transfer Switches (Assoc Emergency Generator).

1. The BMS shall monitor the following points for each automatic transfer switch. Refer to electrical drawings for quantity and location.

a. Connected to normal.

b. Connected to emergency.

c. Normal source available.

d. Emergency source available.

e. Automatic transfer switch, to be provided with Modbus, in load shed.

f. Coordinate with electrical on shedding radiant heat and EV chargers. Coordinate any required time delays for generator.

G. System Integration

1. General

a. Furnish, install, and wire a communications interface between the BMS and the system to be integrated. Furnish, install, and wire all components necessary for a fully operational system interface.

b. Data transfer rate shall be sufficient to maintain data as current to within 15 seconds.

c. Provide one graphic page per floor for each foreign system.

d. The integration modules shall be coordinated, installed and started up prior to the start up and check out of the foreign system. All data shall be checked for accuracy on both sides of the serial interface during the foreign system commissioning process. Provide all labor as required.

2. Fire Alarm System, duct smoke detector to have extra relay and BMS to have a monitoring point.

3. Lighting Control System

4. Security System

H. Miscellaneous Point Monitoring

1. Provide interposing relays as required to monitor discrete digital inputs from equipment provided by others.

1.10 SPECIAL DESIGN CONSIDERATIONS

A. Miscellaneous Monitoring Points

1. Fire Alarm System
2. Water meters
3. Electrical meters
4. Carbon Dioxide sensors as located in plan.

B. Water Leak Detection General Alarm

1. As indicated on plans

PART 2 - PRODUCTS

(Not Applicable)

PART 3 - EXECUTION

(Not Applicable)

END OF SECTION 23 09 10

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SECTION 23 21 13 - HYDRONIC PIPING

PART 1 - PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:

1. Condensate-drain piping.

B. Related Sections include the following:

1. Applicable Sections of Division 23.

1.3 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:

1. Condensate drain piping

a. 150 psig: 200˚F

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Pressure-seal fittings.

2. Piping Specification.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.

2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: Detail, at 1/8 scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Welding certificates. (See Part 3)

C. Field quality-control test reports. (See Part 3)

D. Coordination drawings as outlined in Division 23; Section titled “Basic Mechanical Requirements.”

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. All pipe shall be manufactured in the United States. If the HVAC Contractor elects to purchase piping outside of the United States, the HVAC Contractor, prior to the purchase of the pipe, shall submit complete certifications and typical mill reports in English for review. Pipe purchase outside of the United States and delivered to the project site shall bear identification and mill heat markings and corresponding mill test reports shall be made available.

B. Mill certifications from the pipe supplier shall be made available upon request by the Owner or Engineer.

C. Piping found to be in violation of this specification maybe required to be removed and replace from the project whether or not already installed.

D. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

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

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

E. See Welding procedure requirements in Part 3 of this specification.

F. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Wrought-Copper Fittings: ASME B16.22; ASTM B-32

C. Wrought-Copper Unions: ASME B16.22.

2.2 JOINING MATERIALS

A. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

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

Solder used in Joints	Service Temperatures Deg. F.	¼ to 1 inch Incl.	1 – ¼ to 2 inches Incl.	2 – ½ to 4 inches Incl.	6 inches
95-5 Tin-Antimony	100	500	400	300	260
	150	400	350	275	260
	200	300	250	200	250
	250	200	175	150	250
Brazing Filler Metal* at or above 1000°F	250	300	210	170	150
	350	270	190	155	150

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

B. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

2.3 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Charlotte Pipe and Foundry Company.

b. IPEX Inc.

c. KBi.

2. PVC one-piece fitting with one threaded brass or copper insert and one Schedule 80 solvent-cement-joint end.

B. Plastic-to-Metal Transition Unions:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Charlotte Pipe and Foundry Company.

b. IPEX Inc.

c. KBi.

d. NIBCO INC.

2. MSS SP-107, PVC union. Include brass or copper end, Schedule 80 solvent-cement-joint end, rubber gasket, and threaded union.

2.4 DIELECTRIC FITTINGS

A. General Requirements: Assembly or fitting with separating nonconductive insulating material isolating joined dissimilar metals to prevent galvanic action and stop corrosion.

1. Combination of copper alloy and ferrous materials with separating nonconductive insulating material

2. Threaded, solder, plain, and weld neck end connection types compatible with piping system materials.

3. Insulating material shall be suitable for system fluid, temperature and pressure and shall not restrict flow.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Capitol Manufacturing Company.

b. Central Plastics Company.

c. Hart Industries International, Inc.

d. Jomar International Ltd.

e. Matco-Norca, Inc.

f. McDonald, A. Y. Mfg. Co.

g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

h. Wilkins; a Zurn company.

2. Description:

a. Standard: ASSE 1079.

b. Pressure Rating: Minimum pressure rating equal to pressure rating of piping system installed.

c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Capitol Manufacturing Company.

b. Central Plastics Company.

c. Matco-Norca, Inc.

d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

e. Wilkins; a Zurn company.

2. Description:

a. Standard: ASSE 1079.

b. Factory-fabricated, bolted, companion-flange assembly.

c. Pressure Rating: Minimum pressure rating equal to pressure rating of piping system installed.

d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Advance Products & Systems, Inc.

b. Calpico, Inc.

c. Central Plastics Company.

d. Pipeline Seal and Insulator, Inc.

2. Description:

a. Nonconducting materials for field assembly of companion flanges.

b. Pressure Rating:

c. Gasket: Neoprene or phenolic.

d. Bolt Sleeves: Phenolic or polyethylene.

e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Elster Perfection.

b. Grinnell Mechanical Products.

c. Matco-Norca, Inc.

d. Precision Plumbing Products, Inc.

e. Victaulic Company.

2. Description:

a. Standard: IAPMO PS 66

b. Electroplated steel nipple. complying with ASTM F 1545.

c. Pressure Rating: Minimum pressure rating equal to pressure rating of piping system installed.

d. End Connections: Male threaded, grooved or plain.

e. Lining: Inert and noncorrosive, thermoplastic.

2.5 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23, Section titled "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23, Section titled "Instrumentation and Control for HVAC."

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

PIPE AND PIPE FITTING SCHEDULE (HYDRONIC)			
SERVICE	PIPE SIZE (INCHES)	PIPE MATERIAL	FITTINGS
Drain Piping	4 inches and smaller	ASTM-B88; Hard Drawn Type "L" Copper	Wrought copper; Brazed (B CUP-5); ASME-B16.22; Dielectric Fitting between valves and copper pipe where required
Refrigerant Piping		See Division 23; Section titled "Refrigerant Piping"	See Division 23; Section titled "Refrigerant Piping"

3.2 HYDRONIC PIPING SPECIALTIES INSTALLATION

A. Comply with the requirements in Division 23; Section “Hydronic Piping Specialties” for installation requirements hydronic system appurtenances.

3.3 VALVE APPLICATIONS

A. Furnish and Install valves shown on drawings and/or as necessary for control and easy maintenance of all piping and equipment.

B. See Division 23; Section titled “General-Duty Valves for HVAC Piping for valve requirements.

C. Valves shall have a minimum working pressure and material as specified for the piping system installed in.

D. Ball and butterfly valves shall be installed wherever possible.

E. Furnish and install check valves at each pump discharge and elsewhere as required to control flow direction.

3.4 DIELECTRIC FITTING APPLICATION

A. For all systems, provide dielectric fitting to isolate joined dissimilar materials to prevent galvanic action and stop corrosion.

B. Dielectric fittings shall be of the non-reducing type which shall be suitable for system fluid, pressure and temperature and shall not restrict flow.

C. For factory fabricated equipment, manufacturer shall submit method of compliance or exception (if applicable) in writing as part of the shop drawing.

D. It is the intent of this paragraph that all system components (equipment connections, piping, etc.) whether they are field installed or factory fabricated to comply with subparagraph A above.

3.5 PIPING SYSTEMS--COMMON REQUIREMENTS

A. Install piping as described herein, except where system Sections specify otherwise. Individual piping system specification Sections in Division 23 specify piping installation requirements unique to the piping system.

B. All piping materials shall be compatible for temperature, pressure and service.

C. All piping materials of a given type shall be manufactured by a single source and supplied by a single supplier.

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

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

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

G. Install piping to permit valve servicing.

H. All building service piping (including pressurized piping, condensate vacuum), shall comply with ANSI Standard B31.9 - Building Service Piping, unless noted otherwise.

I. Piping specifications shall be submitted with shop drawings.

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

K. Furnish and install all necessary float devices, aquastats, thermostats, pressure sensors, etc. required for alarm indication as indicated on the HVAC drawing and other applicable sections of Division 23. Drawing and other applicable sections of Division 23.

L. Minimum pipe size shall be 3/4".

M. Install piping at required slope.

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

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

P. Install piping free of sags and bends.

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

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

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

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

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

V. Install couplings according to manufacturer's printed instructions

W. Verify final equipment locations for roughing in.

X. Refer to equipment specifications in other Sections of Division 23 for roughing-in requirements

Y. Piping connections: Except as otherwise indicated, making piping connections as specified below:

1. Install unions in piping 2 ½ inches (65 mm) and smaller adjacent to each valve and a final connections to each piece of hydronic equipment having 3 inch (75 mm) or smaller threaded piping connection.

2. Wet Piping System (water): install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

Z. Branch connections to mains or sub-branch connections to branches (screwed or welded) shall be made with Tee Fitting (full line size) when the branch or sub-branch connection is equal to or one pipe size smaller. Reduce fittings shall be used after the Tee fittings. For branch or sub-branch connections to mains or branches that are two pipe sizes or smaller maybe made utilizing a weld-o-let or thread-o-let (ANSI B16.9). Weld-o-lets or thread-o-let shall have the same schedule and pressure standard as the pipe to which they connect. No branch or sub-branch shall be made by burning a hole in the pipe it connects to and welding connection. No connection shall be made using a saddle type fittings. T-drill connections are not permitted in copper piping system.

AA. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

BB. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

CC. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

DD. Install valves according to Division 23; Section titled "General-Duty Valves for HVAC Piping."

EE. Install unions in piping, 2½ inches (DN 65) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

FF. Identify piping as specified in Division 23; Section titled "Identification for HVAC Piping and Equipment."

GG. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23; Section titled "Sleeves and Sleeve Seals for HVAC Piping."

HH. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

II. Installation of Appurtenances and Sensors in Piping:

1. Provide all fittings, wells and openings required for installation of devices to indicate flow, temperature, pressure, etc., in piping systems.

JJ. Pipe systems shall conform to the following requirements

1. All piping connections to coils and equipment shall be made with offsets and bolted flanges (screwed or welded) arranged so that the coil and/or equipment can be serviced or removed without dismantling piping.

KK. Miscellaneous Drains, Vents and Reliefs shall be provided as follows:

1. Pipe miscellaneous drains, from equipment to the nearest open drain, floor drain or roof drain. Provide drain valves whenever required for complete drainage of piping system, including system side of pumps.

2. Provide cap or plug in all open ended piping systems, all open ended valves for future connections, drains and vents.

LL. All pipe shall be reamed out after cutting to remove all burrs.

3.6 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 23; Section titled "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.

1. See “PIPE HANGER & SUPPORT SCHEDULE” on drawings.

3.7 PIPE JOINT CONSTRUCTION

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

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

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

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

3.8 HYDRONIC ACCESSORIES INSTALLATION

A. Install manual air vents at high points in piping, and elsewhere as required for system air venting.

3.9 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for condensate piping connections shall be run full size of pipe indicated and reduce at terminal equipment.

3.10 PRESSURE TESTING - ALL PIPING SYSTEMS

A. Water shall not be introduced into piping systems for testing without water treatment. All piping systems shall be tested to a hydrostatic pressure at least 1-1/2 times the maximum operating pressure (but not less than 125 psig) for a sufficiently long time, but not less than 4 hours, to detect all leaks and defects. Where necessary, piping shall be tested in sections to permit the progress of the job.

B. Hydrostatic Testing Corrosion Inhibitor

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

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

3.11 PROTECTION AND CLEANING

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

B. The inlet and discharge openings of all equipment shall be kept covered until all local plastering, parging, etc. is completed, and the units are ready to run.

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

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

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

3.12 FLUSHING AND CLEANING OF PIPING

A. All piping systems shall be thoroughly flushed out with the approved cleaning chemicals to remove pipe dope, slushing compounds, cutting oils, and other loose extraneous materials. This also includes any piping systems which are not listed as requiring water treatment.

B. Develop plan for flushing and cleaning piping. Submit plan for approval prior to completion of piping. Provide all temporary and permanent piping, equipment, materials necessary to complete flushing and cleaning.

C. Prior to flushing, temporarily remove, isolate or bypass dirt sensitive equipment and devices.

D. Flush all piping with cold water for a minimum of 6 feet per second for one hour, until water runs clear. Water supply shall be equivalent to piping to be flushed. Drain all low points.

E. Circulate flush water prior to installing cleaning chemicals. Provide cleaning chemicals, under the direction of the chemical supplier. Following flushing, install cleaning chemicals and circulate through the entire system for a minimum of one hour, or as directed by chemical supplier. Take water sample for owner's use. Drain system, including all low points. Flush, drain and fill system, circulate for one hour, sample for owner's use. Drain, flush, fill, circulate and sample until system is free of cleaning chemicals, as indicated by analysis of samples.

F. Provide temporary pumps and piping to chemically clean piping at a minimum velocity of 6 fps without using the system pumps.

G. The cleaning chemicals shall be added by the mechanical trade. The chemical supplier shall verify that the chemicals are compatible with all the materials in the systems. The chemical supplier shall instruct as to the proper feed rates, shall check that the cleaning solution is actually in each system, shall instruct the contractor as to when to flush the system and shall check each system following flushing to ensure all cleaning chemicals have been removed from each system.

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

3.13 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints uninsulated and exposed for examination during test.

2. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.

3. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

4. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.

2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.

3. Determine that hydronic system is full of water.

4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for sufficient time to detect leaks but not less than four (4) hours, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

6. Where necessary, piping maybe tested in sections to permit the progress of the project.

7. If sections of or the entire piping system must be hydrostatically tested prior to cleaning or piping system, an appropriate corrosion inhibitor shall be added to the test water at sufficient levels to totally passive metal and provide protective film on pipe surfaces to prevent corrosion prior to cleanout and chemical water treatment.

8. HVAC Contractor shall be responsible to coordinate the corrosion inhibitor treatment with the Water Treatment Contractor. At no time shall the HVAC Contractor add water to a system without treatment

9. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.

2. Verify lubrication of motors and bearings.

END OF SECTION 23 21 13

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SECTION 23 21 16 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes special-duty valves and specialties for the following:

1. Condensate-drain piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

2. Air-control devices.

3. Hydronic specialties.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated.

1. See Division 23; Section titled “Hydronic Piping” for minimum working pressures and temperature.

2.2 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23; Section titled "General-Duty Valves for HVAC Piping.”

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23; Section titled "Instrumentation and Control for HVAC.”

2.3 AIR-CONTROL DEVICES

A. Manual Air Vents:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Amtrol, Inc.

b. Armstrong Pumps, Inc.

c. Bell & Gossett Domestic Pump.

d. Nexus Valve, Inc.

e. Taco, Inc.

2. Body: Bronze.

3. Internal Parts: Nonferrous.

4. Operator: Screwdriver or thumbscrew.

5. Inlet Connection: NPS 1/2 (DN 15).

6. Discharge Connection: NPS 1/8 (DN 6).

7. CWP Rating: Minimum working pressure rating equal to working pressure rating of piping system.

8. Maximum Operating Temperature: 225 deg F (107 deg C).

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Furnish and install valves shown on drawings and/or as necessary for control and easy maintenance of all piping and equipment.

B. See Division 23; Section titled “General-Duty Valves for HVAC Piping” for valve requirements.

C. Valves shall have a minimum working pressure and material as specified for the piping system installed.

D. Ball and butterfly valves shall be installed wherever possible.

E. Furnish and install check valves at each pump discharge and elsewhere as required to control flow direction.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping and elsewhere as required for system air venting.

END OF SECTION 23 21 16

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SECTION 23 21 23 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Automatic condensate pump units.

1.3 QUALITY ASSURANCE:

A. All equipment or components of this specification section shall meet or exceed the requirements and quality of the items herein specified, or as denoted on the drawings.

B. Ensure pump operation at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate to ANSI/HI 9.6.3.1 standard for Preferred Operating Region (POR) unless otherwise approved by the engineer. The pump NPSH shall confirm to the ANSI/HI 9.6.1-1997 standards for Centrifugal and Vertical Pumps for NPSH Margin.

C. Ensure pump pressure ratings are at least equal to system's maximum operating pressure at point where installed, but not less than specified.

D. Equipment manufacturer shall be a company specializing in manufacture, assembly, and field performance of provided equipment with a minimum of 20 years experience.

E. Regulatory Requirements: Comply with provisions of the following:

1. ASME B31.9 "Building Services Piping" for piping materials and installation.
2. Hydraulic Institute's "Standards for Centrifugal, Rotary & Reciprocating Pumps" for pump design, manufacture, testing, and installation.
3. UL 778 "Standard for Motor Operated Water Pumps" for construction requirements. Include UL listing and labeling.
4. NEMA MG 1 "Standard for Motors and Generators" for electric motors. Include NEMA listing and labeling.
5. NFPA 70 "National Electrical Code" for electrical components and installation.

F. Single-Source Responsibility: Obtain each category of pumps from a single- source and by a single manufacturer. Include responsibility and accountability to answer questions and resolve problems regarding compatibility, installation, performance, and acceptance of pumps.

G. Product Options: Drawings indicate sizes, profiles, connections, and dimensional requirements of pumps and are based on the specific types and models indicated. Other manufacturers' pumps with equal performance characteristics may be considered. Refer to Division 01 Section "Product Substitutions."

1.4 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPT: Ethylene propylene terpolymer.

C. HI: Hydronic Institute.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store pumps in dry location.

B. Retain shipping flange protective covers and protective coatings during storage.

C. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

D. Extended Storage Longer than 5 Days: Dry internal parts with hot air or vacuum-producing device. Coat internal parts with light oil, kerosene, or antifreeze after drying.

E. Comply with pump manufacturer's rigging instructions.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 PUMPS - GENERAL

A. Pump Pressure Ratings: At least equal to system's maximum operating pressure at point where installed, but not less than specified. Factory test at 1.5 times working pressure.

B. Water Temperature: Pump to comply with specific application.

C. Mounting: As described under "Vibration Isolation".

D. Pumps shall be selected to operate at or near their point of peak efficiency thus allowing for operation at capacities of approximately 25% beyond design capacity. In addition, the design impeller diameter shall be selected so that the design capacity of each pump (GPM and TDH) shall not exceed 90% of the capacity obtainable with maximum impeller diameter at the design speed for that model.

E. Rising Curve: Pump characteristic curve shall rise continuously from maximum capacity to shut-off, with shut-off head minimum 10 percent greater than the design head.

F. Working Pressure: Construct pumps for the working pressure in pounds per square inch specified or indicated. Factory test at 1.5 times working pressure.

G. General: Factory assembled and tested.

H. Types, Sizes, Capacities, and Characteristics: As indicated.

I. Motors: Furnish single -speed motors, with type of enclosures and electrical characteristics indicated and as specified under another section of this work. Include built-in thermal-overload protection and grease-lubricated ball bearings. Select each motor to be nonoverloading over full range of pump performance curve.

J. Factory Finish: Manufacturer's standard paint applied to factory-assembled and -tested units before shipping.

K. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs

L. Factory Tests: The pumps shall be factory tested, thoroughly cleaned and painted with (1) coat of machinery enamel prior to shipment. The manufacturer shall include a set of installation instructions with the pumps at the time shipment.

2.2 AUTOMATIC CONDENSATE PUMP UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Beckett Corporation.
2. Hartell Pumps Div.; Milton Roy Co.
3. Little Giant Pump Co.
4. Mepco, LLC.

B. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch- (1800-mm-) minimum, electrical power cord with plug.

C. Capacities and Characteristics:

1. See drawings for Pump capacities and characteristics.

PART 3 - EXECUTION

3.1 COORDINATION

A. Verify that location allows adequate access for proper maintenance, including removing motors, impellers, couplings and accessories.

3.2 EXAMINATION

A. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 PUMP INSTALLATION

A. Install pumps according to manufacturer's written installation and alignment instructions.

B. Comply with requirements of Hydronic Institute’s HI 1.4 or HI 2.4 Standards for Centrifugal, Rotary & Reciprocating Pumps, "Instructions for Installation, Operation and Maintenance.

C. Independently support pumps and suction and discharge piping so the weight of the piping is not supported by the pumps and the weight of the pumps in not supported by the piping.
1.

3.4 ALIGNMENT

A. HVAC Contractor shall perform alignment service for all pumps.

B. Comply with pump and coupling manufacturers' written instructions.

3.5 CONNECTIONS

A. Comply with the requirements for piping specified in the following sections of Division 23; titled

1. Meters and Gages
2. General Duty Valves
3. Hangers and Supports
4. Hydronic Piping
5. Other applicable Sections of Division 23

B. Install piping to allow for proper pump service and maintenance

C. Suction and discharge piping shall be brought to equipment and pump connections in such a manner so as to prevent the possibility of any loads or stresses being applied to the connections or piping. All piping shall be fitted to the pumps even though piping adjustments may be required after the pipe is installed.

D. Pipe diameter of piping for pumps suction and discharge shall be equal to or greater than diameter of pump suction and discharge connections.

E. Install check valve, shut off valve or combination balancing/shut-off valve on pump discharge piping.

F. Install shut-off valves on pump suction. Where there is less than 5 straight pipe diameters of pipe at the pump suction, provide a pump suction diffuser at pump suction.

G. Where reduction from line size to pump connection, connection shall be made with eccentric reducers attached to the pump with tops flat to allow continuity of flow.

H. Pumps with mechanical seals install flushing line and where required return/drain line.

I. Install gate valve and check valve on the discharge pipe from each automatic condensate units.

J. Electric power connections shall be provided as part of the work of Division 26. HVAC contractor shall review with Contractor for Division 26 to ensure connection are in accordance with pump manufacturer's recommendation.

K. Provide pipe wells and other appurtenances required for the work of Division 23 Sections titled "Instrumentation and Control of HVAC Equipment" and "Sequence of Operation for HVAC Controls".

3.6 FIELD QUALITY CONTROL

A. Check suction piping connections for tightness to avoid drawing air into pumps.

B. Check Alignment.

C. Verify that piping is not supported by pump.

D. Set pump controls.

E. Guarantee: Pump to deliver required GPM against design and within ±3% without over-heating motor, bearings or any other parts and without producing noise audible outside the space in which the pumps are installed. Certified test statements to be provided for each pumping unit. Seals to be replaced without charge if faulty operation or unusual wear occurs during guarantee period, not caused by maintenance faults.

3.7 START-UP

A. Start -up: Pumps shall be installed in accordance with the standards of the Hydraulic Institute.

B. Final Checks Before Startup: Perform the following preventive maintenance operations and checks before startup:

1. Lubricate bearings.
2. Remove grease-lubricated bearing covers, flush bearings with kerosene, and clean thoroughly. Fill with new lubricant according to manufacturer's recommendations.
3. Disconnect coupling and check motor for proper rotation that matches direction marked on pump casing.
4. Check that pumps are free to rotate by hand.
5. Check that pump controls are correct for required application.
6. HVAC Contractor shall have a manufacturer’s representative/engineer check the motors and pumps for proper alignment glands for proper tightness, seal flushing system, all bearings for proper lubrication, etc. before pumps are started. If manufacturer’s representative/engineer finds any of the pumps components that are not in accordance manufacturer’s requirements or specifications, defects shall be corrected and re-examined by manufacturer’s representative/engineer.
7. Manufacturer’s representative/engineer shall submit a certified letter stating that the pumps are installed with manufacturer’s recommendations.
8. The HVAC Contractor shall instruct the Testing and Balancing Subcontractor to take amperage readings on each phase of all pump motors and after 15 days Of operation the HVAC Contractor shall recheck and adjust as required alignment and gland tightness and bearing lubrication.

C. Starting procedure for pumps starting against shut-off head (pump discharge valve closed) and with non-overloading motor.

1. Prime pumps, opening suction valve, closing drains, and preparing pumps for operation.
2. Open water supply valves water supply to bearings, where applicable.
3. Open sealing liquid supply valves if pumps are so fitted.
4. Open warm-up valves of pumps handling hot liquids if pumps are not normally kept at operating temperature.
5. Open circulating line valves if pumps should not be operated against dead shutoff.
6. Start motors.
7. Open discharge valves slowly.
8. Check general mechanical operation of pumps and motors.
9. Close circulating line valves once there is sufficient flow through pumps to prevent overheating.

D. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for detailed requirements for testing, adjusting, and balancing hydronic systems.

E. When pumps are to be started against closed check valves with discharge shutoff valves open, steps are the same, except that discharge valves are opened sometime before motors are started.

F. Refer to Division 23 Section titled "Testing, Adjusting, and Balancing for HVAC" for detailed requirements for testing, adjusting, and balancing hydronic systems.

1. Testing, adjusting and balancing shall be provided as part of the work of the above referenced Section. HVAC Contractor shall assist Testing Adjusting and Balancing Subcontractor as required with labor and material.

END OF SECTION 23 21 23

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SECTION 23 23 00 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract including but not limited to

1. General and Supplementary Conditions

2. Division 01 Specification Sections

3. Division 23; Section titled "Vibration Controls for Mechanical Electrical Systems (Non-Seismic)"

4. Division 23; Section titled "Hangers and Supports for HVAC Piping and Equipment"

5. Other Applicable Sections of Division 23

6. Division 07; Section titled "Roof Accessories"

1.2 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications. Include but not be limited to

1. Pipe, tubing, fittings and specialties

2. Special duty valves

3. Refrigerants

1.3 PERFORMANCE REQUIREMENTS

A. The following subparagraphs are minimum test requirements. HVAC Contractor to coordinated with equipment manufacturer to determine the working pressure of the various types of piping system.

1. If working pressure times 1.5 is less than test pressures listed in the following subparagraph, piping system shall be tested at listed pressures in the following subparagraph.

2. If working pressure times 1.5 is greater than test pressures listed in following subparagraphs, test piping systems at higher pressures.

B. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).

2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).

3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:

1. Thermostatic expansion valves.

2. Solenoid valves.

3. Hot-gas bypass valves.

4. Filter dryers.

5. Strainers.

6. Pressure-regulating valves.

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

1. Shop Drawing Scale: Same scales as shop drawing for ductwork and piping shop drawings are being prepared at.

2. Refrigerant piping indicated on Drawings is schematic only. HVAC Contractor in conjunction with equipment manufacturer shall size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

D. Comply with requirements of ASTM 828 “Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings.

E. ANSI/AWS A5.8 “Specification for Filler Metals for Brazing.”

F. ANSI/AWS A5.31 “Specification for Fluxes for Brazing and Braze Welding.”

G. ANSI/AWS B2.2 “Standard for Brazing Procedure and Performance Qualification.”

H. ASME B16.22 “Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.”

1.8 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.9 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type L. Tubing shall be factory cleaned, ready for installation, and have ends capped to protect cleanliness of pipe interiors prior to shipping.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8.

F. Flexible Connectors:

1. Body: Seamless tin/bronze core with high tensile bronze braid jacket.

2. End Connections: Socket ends.

3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.

4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).

5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.2 REFRIGERANT VALVES

A. General;

1. Refrigerant valves and specialties assemblies shall be UL listed and conform to AHRI 760 where applicable.

B. Globe Valve

1. Body; Cast bronze body with cast bronze or forged brass wing cap and bolted bronze bonnet

2. Replaceable resilient disc (compatible with refrigerant valve installed)

3. Plated steel stem

4. Working Pressure Rating; Minimum 400 Psig

5. Operating Temperature; 275°F

6. Valve capable of being repacked under pressure

7. End Connection; Socket (solder)

C. Ball Valve

1. Body; Foraged Brass with brass seal cap and full port construction to match line size interior diameter

2. Ball; Chromium-plated, internally equalized ball design

3. Seal; Compatible with CFC, HCFC and HFC refrigerant and oils

4. Stem; Rupture-proof encapsulated design

5. Manual valve positioning

6. Maximum Working Pressure; 700 Psig

7. Operating Temperature Range; -40°F to 300°F

8. UL/cUL listed; CE certified

9. End Connection; Socket (solder)

10. Where required, provide motorized actuator; gradual open/close to eliminate water hammer; manual override and valve positioning; electronic overload protection; electric power as required by system design.

D. Check Valves (5/8 inch and smaller)

1. Body; Cast brass with straight through "Y" type design
2. Bonnet; Screwed type for access to internal components.
3. Compatible with CFC, HCFC and HFC refrigerant and oils
4. Pressure Drop; Internal components design to limit pressure drop to < 1 Psi
5. Valve design to allow for easy removable of components for replacement
6. Spring; Stainless steel
7. Seat; Teflon
8. Maximum Working Pressure; 700 Psig
9. Operating Temperature Range; -40°F to 300°F
10. Maximum Opening Pressure; 0.50Psig
11. UL/cUL listed; CE certified
12. End Connection; Socket (solder)

E. Check Valve (7/8 inch and larger)

1. Body; Cast brass with straight through "Y" type design
2. Bonnet; Bolted type (four-bolt design) for access to internal components.
3. Compatible with CFC, HCFC and HFC refrigerant and oils
4. Pressure Drop; Internal components design to limit pressure drop to < 1 Psi
5. Valve design to allow for easy removable of components for replacement
6. Spring; Stainless steel
7. Seat; Teflon
8. Gasket Material; Non-asbestos compatible with refrigerants and oils
9. Maximum Working Pressure; 700 Psig
10. Operating Temperature Range; -40°F to 300°F

11. Maximum Opening Pressure; 0.50Psig

12. UL/cUL listed; CE certified

13. End Connection; Socket (solder)

F. Strainer

1. Body; Forged brass; "Y" pattern design

2. Screen; Stainless steel; 100 mesh

3. Screwed cleanout plug

4. Maximum Working Pressure; 700 Psig

5. Operating Temperature Range; -40°F to 300°F

6. UL/cUL listed; CE certified

7. End Connection; Socket (solder)

G. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.

2. Diaphragm: One phosphor bronze and two stainless steel with stainless-steel spring.

3. Operator: Rising stem and hand wheel.

4. Seat: Nylon.

5. End Connections: Socket, union, or flanged.

6. Working Pressure Rating: 500 psig (3450 kPa).

7. Maximum Operating Temperature: 275 deg F (135 deg C).

8. Hermetic seal between bonnet, diaphragm and body

9. Positive backseating with valve in wide open position

10. Non-directional flow

11. Diaphragm replaceable under line pressure

H. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.

2. Packing: Molded stem, back seating, and replaceable under pressure.

3. Operator: Rising stem.

4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.

5. Seal Cap: Forged-brass.

6. End Connections: Socket, union, threaded, or flanged.

7. Working Pressure Rating: 500 psig (3450 kPa).

8. Maximum Operating Temperature: 275 deg F (135 deg C).

I. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.

2. Core: Removable ball-type check valve with stainless-steel spring.

3. Seat: Polytetrafluoroethylene.

4. End Connections: Copper spring.

5. Working Pressure Rating: 500 psig (3450 kPa).

2.3 REFRIGERANT SPECIALTIES

A. Refrigerant valves and specialties assemblies shall be UL listed and conform to AHRI 760 where applicable

B. Moisture/liquid Indicators

1. Body; Forged brass

2. Window; Replaceable, clear, fused glass with indicating element protected by filter screen

3. Indicator; Color coded to show moisture content in parts per million (ppm)

4. Maximum Working Pressure; 500 Psig

5. Maximum Operating Temperature ; 240°F

6. UL/cUL listed; CE certified

7. End Connection; Socket (solder)

8. Compatible with CFC, HCFC and HFC refrigerant and oils

C. Filter Dryer

1. Comply with requirements of AHRI 730
2. Replaceable core design
3. Body & Cover; Painted steel shell with ductile iron cover stainless steel screws and neoprene gaskets
4. Filer Media; design to filter down to 25 micron
5. Desiccant Media; Activated Alumina; Ratio of desiccant media and molecular sieve as recommended by refrigerant manufacturer for both liquid line and suction filter dryers.
6. End Connections; Socket or flare per piping system design
7. Access Ports; For suction line filter dryer only, schraeder access valves at inlet and outlet.
8. Maximum Pressure Drop; Less than 2 Psig
9. Working Pressure; 500 Psig for all refrigerants except R 410A. R 410A 660 Psig
10. Maximum Operating Temperature; 240°F

D. Permanent Filter Dryer

1. Comply with requirements of AHRI 730
2. Permanent core design
3. Body; Painted steel shell
4. Filer Media; design to filter down to 25 micron
5. Desiccant Media; Activated Alumina; Ratio of desiccant media and molecular sieve as recommended by refrigerant manufacturer for both liquid line and suction filter dryers.
6. End Connections; Socket or flare per piping system design
7. Access Ports; For suction line filter dryer only, schraeder access valves at inlet and outlet.
8. Maximum Pressure Drop; Less than 2 Psig
9. Working Pressure; 500 Psig for all refrigerants except R 410A. R 410A 660 Psig
10. Maximum Operating Temperature; 240°F

E. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.

3. Seat: Polytetrafluoroethylene.

4. End Connections: Threaded.

5. Electrical: Molded, watertight coil in NEMA 4 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter. Coil voltage as required by system requirements.

6. Working Pressure Rating: 400 psig (2760 kPa).

7. Maximum Operating Temperature: 240 deg F (116 deg C).

8. Manual operator.

F. Safety Relief Valves: Comply with ASHRAE Standard 15 and ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.

2. Piston, Closing Spring, and Seat Insert: Stainless steel.

3. Seat Disc: Polytetrafluoroethylene.

4. End Connections: Threaded.

5. Working Pressure Rating: 400 psig (2760 kPa).

6. Maximum Operating Temperature: 240 deg F (116 deg C).

G. Thermostatic Expansion Valves: Comply with AHRI 750.

1. Body, Bonnet, and Seal Cap: Forged brass.

2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.

3. Packing and Gaskets: Non-asbestos.

4. Capillary and Bulb: Copper tubing filled with refrigerant charge.

5. Suction Temperature: As required per system design.

6. Superheat: Adjustable.

7. Reverse-flow option (for heat-pump applications).

8. End Connections: Socket, flare, or threaded union.

9. Working Pressure Rating; As required for refrigerant type but not less than 450 psig.

10. External equalizer line

11. Valve design specific for refrigerant type

12. Distributer with side connection for hot gas by-pass connection

13. Balance port design.

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.

1. Body, Bonnet, and Seal Cap: Ductile iron or steel.

2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.

3. Packing and Gaskets: Non-asbestos.

4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.

5. Seat: Polytetrafluoroethylene.

6. Equalizer: External.

7. Electrical: Molded, watertight coil in NEMA 4 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter. Coil voltage as required by system requirements. .

8. End Connections: Socket.

9. Set Pressure: As required by system design.

10. Throttling Range: Maximum 5 psig (34 kPa).

11. Working Pressure Rating: 500 psig (3450 kPa).

12. Maximum Operating Temperature: 240 deg F (116 deg C).

I. Evaporator Pressure Regulator Valves

1. Body; Forged Brass

2. Pilot-operate

3. Solenoid stop to close valve during system defrost cycle

4. Normally open design to allow for system evacuation without manual operator. If normally closed design required for system operation, provide manual operator

5. Worker Pressure Rating; 450 psig

6. Maximum Fluid Temperature; 240°F

7. Agency Listing; UL/ULc listed.

8. End Connection; Socket.

J. Mufflers:

1. Body: Welded steel with corrosion-resistant coating.

2. End Connections: Socket or flare.

3. Working Pressure Rating: 500 psig (3450 kPa).

4. Maximum Operating Temperature: 275 deg F (135 deg C).

K. Receivers: Comply with AHRI 495.

1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

2. Comply with UL 207; listed and labeled by an NRTL.

3. Body: Welded steel with corrosion-resistant coating.

4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.

5. End Connections: Socket or threaded.

6. Working Pressure Rating: 500 psig (3450 kPa).

7. Maximum Operating Temperature: 275 deg F (135 deg C).

L. Liquid Accumulators: Comply with AHRI 495.

1. Body: Welded steel with corrosion-resistant coating.

2. End Connections: Socket or threaded.

3. Working Pressure Rating: 500 psig (3450 kPa).

4. Maximum Operating Temperature: 275 deg F (135 deg C).

2.4 REFRIGERANTS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Atofina Chemicals, Inc.

2. DuPont Company; Fluorochemicals Div.

3. Honeywell, Inc.; Genetron Refrigerants.

4. INEOS Fluor Americas LLC.

B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 4 (DN 100) and Smaller for Conventional Air-Conditioning Applications: Copper, Type L (B), drawn-temper tubing and wrought-copper fittings.

B. Hot-Gas and Liquid Lines: Copper, Type L (B), annealed- or drawn-temper tubing and wrought-copper fittings.

C. Safety-Relief-Valve Discharge Piping: Copper, Type L (B), annealed- or drawn-temper tubing and wrought-copper fittings.

3.2 EXAMINATION

A. Examine rough in for refrigerant piping systems to verify actual locations of piping connections prior to installation.

3.3 PIPING INSTALLATIONS

A. Drawing are diagrammatic and indicate general location and arrangement of piping system. Install piping as indicated unless deviations are approved on Shop Drawing.

B. General: Install refrigerant piping in accordance with ASHRAE Standard 15 "The Safety Code for Mechanical Refrigeration."

C. Install piping in as short and direct arrangement as possible to minimize pressure drop.

D. Install piping for minimum number of joints using as few elbows and other fittings as possible.

E. Arrange piping to allow normal inspection and servicing of compressor and other equipment. Install valves and specialties in accessible locations to allow for servicing and inspection.

F. Provide adequate clearance between pipe and adjacent walls and hanger, or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit installation of full thickness insulation.

G. Install piping in areas where piping is exposed, mechanical room and service areas at right angles or parallel to building walls. Diagonal pipe runs are prohibited unless specifically indicated otherwise.

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

I. Install piping adjacent to equipment to allow for service and maintenance.

J. Insulate suction lines. Liquid line are not required to be insulated, except where they are installed adjacent and clamped to suction lines, where both liquid and suction lines shall be insulated as a unit.

K. Do not install insulation until system testing has been completed and all leaks have been eliminated.

L. Install branch tie in lines to parallel compressors equal length, and pipe identically and symmetrically.

M. Install copper tubing in rigid conduit in locations where copper tubing will be exposed to mechanical injury.

N. Slope refrigerant piping as follows:

1. Install horizontal hot gas discharge piping with 1/2" per 10 feet downward slope away from the compressor.

2. Install horizontal suction lines with 1/2 inch per 10 feet downward slope to the compressor, with no long traps or dead ends which may cause oil to separate from the suction gas and return to the compressor in damaging slugs.

3. Install traps and double risers where indicated, and where required to entrain oil in vertical runs.

4. Liquid lines may be installed level.

O. Use fittings for all changes in direction and all branch connections.

P. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

Q. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

R. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

S. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1 inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

T. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

U. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6 inch shall be steel; pipe sleeves 6 inch and larger shall be sheet metal.

V. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.

W. Install strainers immediately upstream and adjacent to the following unless they are furnished as an integral assembly for device being protected:

1. Solenoid valve
2. Thermostatic expansion valve
3. Hot gas by-pass valve
4. Compressor
5. At other system components in piping system that require protection.

X. Install moisture/liquid indicators in liquid lines between filter/driers and thermostatic expansion valves and in liquid line to receiver.

1. Install moisture/liquid indicators in lines larger than 2 1/8 inch OD, using a bypass line.

Y. Install unions to allow removal of solenoid valves, pressure regulating valves, expansion valves, and at connections to compressors and evaporators.

Z. Install flexible connectors at the inlet and discharge connection of compressors.

AA. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

BB. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

CC. Identify refrigerant piping and valves according to Division 23; Section titled "Identification for HVAC Piping and Equipment."

DD. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23; Section titled "Sleeves and Sleeve Seals for HVAC Piping."

EE. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23; Section titled "Sleeves and Sleeve Seals for HVAC Piping."

FF. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23; Section titled "Escutcheons for HVAC Piping."

3.4 VALVE AND SPECIALTY APPLICATIONS

A. General: Install refrigerant valves where indicated, and in accordance with manufacturer's instructions.

B. Install globe valves on each side of strainers and driers, in liquid and suction lines at evaporators, and elsewhere as indicated.

C. Install a full sized, 3 valve bypass around each drier.

D. Install solenoid valves ahead of each expansion valve and hot gas bypass valve. Install solenoid valves in horizontal lines with coil at the top.

1. Electrical wiring for solenoid valves is installed by this contractor to meet requirements specified in Division 26. Coordinate electrical requirements and connections.

E. Thermostatic expansion valves may be mounted in any position, as close as possible to the evaporator.

1. Where refrigerant distributors are used, mount the distributor directly on the expansion valve outlet.

2. Install the valve in such a location so that the diaphragm case is warmer than the bulb.

3. Secure the bulb to a clean, straight, horizontal section of the suction line using two bulb straps. Do not mount bulb in a trap or at the bottom of the line.

4. Where external equalizer lines are required make the connection where it will clearly reflect the pressure existing in the suction line at the bulb location.

F. Install Compressor shut-off valves in suction and discharge lines of compressor.

G. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

H. Install a check valve at the compressor discharge and a liquid accumulator (where required by manufacturer) at the compressor suction connection.

I. Except as otherwise indicated, install either diaphragm packless or packed-angle valves on inlet and outlet side of filter dryers.

J. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve.

L. Where compressor manufacturer additional protection, install a suction filter/dryer in suction line at compressor inlet.

M. Install receivers sized to accommodate pump-down charge.

N. Install flexible connectors at compressors.

3.5 PIPE JOINT CONSTRUCTION

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

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

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing, to prevent scale formation.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.

2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

E. Mechanical fittings (crimp or flare) are not permitted

3.6 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Division 23; Section titled "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.

2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6 m) or longer.

3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.

4. Spring hangers to support vertical runs.

5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Support multifloor vertical runs at least at each floor.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.

2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.

3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.

a. Fill system with nitrogen to the required test pressure.

b. System shall maintain test pressure at the manifold gage throughout duration of test.

c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.

d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.8 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.

2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.

3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).

4. Charge system with a new filter-dryer core in charging line.

3.9 ADJUSTING AND CLEANING

A. Before installation of copper tubing, clean the tubing and fitting using following cleaning procedure:

B. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through the tubing by means of a wire or an electrician's tape.

C. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.

D. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.

E. Finally, draw a clean, dry, lintless cloth through the tube or pipe.

F. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

G. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

H. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

I. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.

2. Verify that compressor oil level is correct.

3. Open compressor suction and discharge valves.

4. Open refrigerant valves except bypass valves that are used for other purposes.

5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

J. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 23 23 00

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SECTION 23 31 13 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.

2. Single-wall round ducts and fittings.

3. Sheet metal materials.

4. Duct liner.

5. Sealants and gaskets.

6. Hangers and supports.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.

2. Section 230713 Duct Insulation.

3. Section 230720 Acoustical Duct Lining and Duct Wrap.

4. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, seal and leakage classification shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravityloads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.

2. Sealants and gaskets.

3. Leakage test procedure and calculations for review and approval for all duct sections/segments subject to leak testing.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

3. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."

4. Duct-Cleaning Test Report for Prerequisite IEQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-up."

5. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content. “

6. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.

2. Factory- and shop-fabricated ducts and fittings.

3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.

4. Elevation of bottom of ducts.

5. Dimensions of main duct runs from building grid lines.

6. Fittings.

7. Reinforcement and spacing.

8. Seam and joint construction.

9. Penetrations through partitions.

10. Equipment installation based on equipment being used on Project.

11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.

12. Hangers and supports, including methods for duct and building attachmentand vibration isolation.

D. Design Submittal:

1. Sheet metal thicknesses.

2. Joint and seam construction and sealing.

3. Reinforcement details and spacing.

4. Materials, fabrication, assembly, and spacing of hangers and supports.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout to accommodate other building services. See Spec Section 230000 titled “Basic Mechanical Requirements”.

2. Items penetrating finished ceiling including the following:

a. Lighting fixtures.

b. Air outlets and inlets.

c. Speakers.

d. Sprinklers.

e. Access panels.

f. Perimeter moldings.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. SMACNA HVAC Duct Construction Standards, Metal and Flexible, Third Edition, 2005.

B. SMACNA HVAC Air Duct Leakage Test Manual, Second Edition, 2012.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

1.7 DEFINITIONS

A. Sealing Requirement Definitions: For the purposes of duct systems sealing specified in this Section, the following definitions apply:

1. Seams: A seam is defined as jointing of two longitudinally (in the direction of air flow) oriented edges of duct surface material occurring between two joints. All other duct surface connection made on perimeter are deemed to be joints.

2. Joints: Joints include transverse joints, offsets and transitions, girth joints, louver and air terminal connection to ducts; elbows access panel frames and jamb; duct, plenum, and casing abutments to building structures.

3. Wall penetrations: Include duct fittings, branch and subbranch connections, tees (figure 4-6), divided flow branches, duct collar tap-ins, access doors, etc. (SMACNA Figures 4-5 & 4-6)

1.8 SYSTEM PERFORMANCE REQUIREMENTS

A. The duct system design, as indicated, has been used to select and size air moving and distribution equipment and other components of the air system. Changes or alternation to the layout or configuration of the duct system must be specifically approved in writing. Accompany requests for layout modification with calculations showing that the proposed layout will provide the original design results without increasing the system total pressure.

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" Chapter 2 Rectangular Duct Construction based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Button punch and snap lock is not acceptable. (SMACNA Figure 2-2, Type L-2)

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches (1524 mm) in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90 (Z275).

2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

D. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

1. Tie Rods: Tie-rod attachments, joint and mid panel tie-rod applications shall be in accordance with SMACNA HVAC Duct Construction Manual sections 2.5 thru 2.9.

2.4 SPECIAL DUCTWORK CONSTRUCTION

A. Ductwork required to be removable shall be companion flanged SMACNA Type T-22.

B. Ductwork systems serving areas of high humidity shall be constructed of stainless steel 316L, or aluminum with gauges in accordance with SMACNA Standards as referenced above (minimum 16 gage). Ductwork shall be continuously welded or soldered watertight. Pitch duct to low point drains. Pipe drains (1" copper drain line) to floor drains or utility sinks.

1. Areas include

a. Exhaust ductwork exposed on roof.

C. Ductwork exposed to weather

1. After exposed ducts and joints are sealed and tested as specified, apply over and around the same areas of possible leakage (joints), an approved sealer system. Ductwork outside the building shall be installed in a manner to result in A SMACNA leakage classification of 4 for rectangular and (2) for round ducts.

2. Exposed supply and return air ductwork shall be insulated and weather-protected as specified under duct insulation specification, Section 230713, Item 2.14 weatherproofing finishes for outdoor ductwork (supply return, exhaust). Insulate after the ductwork installation has been completed and leak tested.

2.5 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.

2. Tape Width: 3 inches (76 mm) 4 inches (102 mm) 6 inches (152 mm).

3. Sealant: Modified styrene acrylic.

4. Water resistant.

5. Mold and mildew resistant.

6. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.

7. Service: Indoor and outdoor.

8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

11. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.

2. Solids Content: Minimum 65 percent.

3. Shore A Hardness: Minimum 20.

4. Water resistant.

5. Mold and mildew resistant.

6. VOC: Maximum 75 g/L (less water).

7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.

8. Service: Indoor or outdoor.

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

11. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

12. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.

13. Service: Indoor or outdoor.

14. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.

2. Type: S.

3. Grade: NS.

4. Class: 25.

5. Use: O.

6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage classification of 2 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.

2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.

3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.

3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings. Changes in duct sizes and location to conform to space conditions or coordination with other building services shall be made at no additional cost to the Owner.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible". If local codes require other standards that are more stringent, local codes shall govern.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

K. Protect duct interiors from moisture, construction debris and dust, and other foreign materials.

L. All required supports, hangers, anchors, and guides shall be provided and installed by this contractor.

M. All ductwork; register boxes, air chambers, dampers, and all auxiliary work of any kind, necessary to make the various air conditioning, ventilating and heating systems of the building complete and ready for operation, shall be furnished and installed.

N. Dimensions given on drawings of all acoustically lined ducts shall be the clear inside dimension. Refer to "Acoustical Treatment".

O. Where the trade elects to use "Duct-Mate" for joints or similar product, PVC clips are not permitted (use metal) and all corners shall be bolted (boltless connectors are not permitted) except where local codes permit Duct-Mate joints as breakaway connection at fire dampers. Only gaskets manufactured by Duct-Mate are acceptable.

P. Use gasketed type joint when dissimilar metals are joined.

Q. All ductwork unless otherwise noted shall be hung with 1 in. x 1/8 in. galvanized iron bands. Ductwork with cross sectional area under 4 square feet shall be hung on 8'-0 in. centers. For ducts with a cross-sectional area of more than 4 sq. ft. but not over 10 sq. ft. hangers shall be no more than 6 feet apart, and for ducts with a cross sectional area of more than 10 sq. ft. hangers shall be no more than 4 ft. apart. All hangers shall be bent (2" minimum) under the bottom as well as the sides and secured with sheet metal screws.

R. Where ducts are stacked they shall be independently supported as above or shall be supported per SMACNA Duct Construction Standards - Metal and Flexible Chapter 5.

S. All ductwork shall be substantially built with approved joints and seams smooth on the inside and a neat finish on the outside. Duct joints as near airtight as possible, with laps made in the direction of air flow and no flanges projecting into the air stream. Ducts shall be adequately braced to prevent vibration. All angles shall be galvanized or shop painted with two coats of rust resistant paint.

T. Changes in shape and dimension shall conform to the following:

1. For increases in cross-sectional area, the shape of the transformation shall not exceed 1" in 7".

2. For reductions in area the slope may be 1" in 4" but 1" in 7" is preferred.

U. Changes in direction shall conform to the following:

1. Unvaned elbow with throat radius not less than ½ the width of the duct.

2. Square elbows with single vane turning vanes shall be as per SMACNA with 3-1/4" spacing and are acceptable in ducts with not more than 2200 FPM air velocity. For higher velocities, use sweep type vanes.

V. Turning vanes shall be single blade turning vanes fabricated from the same material as the duct. Large radius vanes shall be used. The maximum unsupported vane length shall not exceed 36". Tab spacing shall be SMACNA standard. Vanes shall be welded to runners. Rail systems with non-standard tab spacings shall not be accepted. All tabs shall be used, do not skip tabs. Mounting rails shall have friction insert tabs which align the vanes automatically. Vanes shall be subjected to tensile loading and be capable of supporting 250 lbs when fastened per the manufacturer's instructions.

W. Wherever it may be necessary to make provisions for vertical hangers of the ceiling construction passing through ducts, provide streamlined shaped sleeves around such ceiling construction hangers as to fully protect the duct from being punched with holes for the passage of such hangers. Any such streamlined sleeves shall be made airtight at top and bottom of ducts. In no case shall there be more than two rods in any 9 sq. ft. area. No rods shall pierce ducts smaller than 12" in horizontal area.

X. Where automatic dampers are shown on drawings or are required, their selection shall be made so that the frames, stops, etc. of such dampers are outside of the airstream so as to provide a nominal 100% free area damper.

Y. Furnish and install manual dampers, registers, grilles, register boxes, access doors, sound traps, etc., as described elsewhere in the specifications and as required for a complete system, ready for operation.

Z. Exact dimensions of register boxes must await approval of grilles, and exact locations shall be submitted for approval, otherwise any changes directed after installation shall be made without additional cost. All register boxes and other opening of the ductwork must be kept tightly closed during construction to keep out rubbish.

AA. Access doors as specified elsewhere shall be provided in the ducts wherever required for access to dampers or other controls.

BB. Provide No. 16 USSG, 3/4" wire mesh screen over each open return duct in hung ceiling unless register or grille is shown.

CC. Dryer exhaust shall be constructed and assembled without the use of sheet metal screws in longitudal seams. The interior surface of the duct shall be smooth without any projections. If overlap joints are used to assemble the duct sections, the male end of the overlap shall extend in the direction of air flow. Sheetmetal screws shall not protrude more than 1/8” in the air stream and joints shall be covered with UL listed duct tape. Provide a cleanout at the base of each dryer riser.

DD. Only flexible ductwork listed, labeled, and in compliance with UL 2158A shall be used for dryer transition ducts. Dryer transition ducts must be a single length with no connecting sections allowed. Dryer transition ducts shall not be concealed within construction, such as passing through floors, walls, hidden spaces, etc., or be longer than 8 feet.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in Item 3.14 of this specification duct schedule.

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2. Outdoor, Supply-Air Ducts: Seal Class A.

3. Outdoor, Exhaust Ducts: Seal Class C.

4. Outdoor, Return-Air Ducts: Seal Class C.

5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.

6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.

7. Unconditioned Space, Exhaust Ducts: Seal Class C.

8. Unconditioned Space, Return-Air Ducts: Seal Class B.

9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C.

10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class B.

11. Conditioned Space, Exhaust Ducts: Seal Class B.

12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.

2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.

4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

G. Hanger and supports for ducts requiring lagging and/or dry-wall enclosure shall include the additional weight of the lagging and/or dry-wall enclosure.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Duct Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test. Test ducts in accordance with Item 3.14 Duct Schedule for duct system construction static pressure, seal classification and leakage classification.

2. Duct leakage testing shall be conducted during construction phase where full access to risers are available and leakage testing can be 100% completed prior to construction enclosing then.

3. Test the following systems:

   a. All ducts (supply, return, exhaust etc.) Pressure Class +/- 2" W G. and higher, before insulation is applied shall be pressure tested at scheduled external static pressure and joints for all mains, risers and branches shall be check for leakage and repair if necessary. Noisy and whistling leaks shall be repaired, and the system shall then be retested

      (1) Duct risers shall be constructed to minimum 3" static pressure classification and/or higher pressure classification as called for on duct schedule.

   b. Supply Ducts with a Pressure Class 2-inch wg (500 Pa) and Higher: Test representative duct sections, totaling no less than 100 percent of total installed duct area for each designated pressure class.

   c. Return Ducts with a Pressure Class 2-Inch wg (500 Pa) and Higher: Test representative duct sections, totaling no less than 100 percent of total installed duct area for each designated pressure class.

   d. Exhaust Ducts with a Pressure Class 2-Inch wg (500 Pa) and Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.

   e. Outdoor Air Ducts with a Pressure Class 2-Inch wg (500 Pa) and Higher: Test representative duct sections, totaling no less than 100 percent of total installed duct area for each designated pressure class.

4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

5. Test for leaks before applying external insulation.

6. Conduct tests at static pressures equal to maximum design duct static pressure classification of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above the scheduled duct static pressure classification.

7. Give ten days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.

2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

    a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.8 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.

2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.

3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.

2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).

2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.

3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, filters and filter sections, and condensate collectors and drains.

4. Coils and related components.

5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.

6. Supply-air ducts, dampers, actuators, and turning vanes.

7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.

2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.

3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.

4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

6. Provide drainage and cleanup for wash-down procedures.

7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.9 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

A. Fabricate ducts as indicated in the following schedule:

B. Duct static pressure classification means static pressure classification in the SMACNA HVAC Duct Construction Standards Metal and Flexible.

C. The column titled “SMACNA Leakage Classification” the designation 4 (2) means the “4” the leakage classification for rectangular duct and “(2)” the leakage classification for round ducts.

DUCT SCHEDULE					
DUCT SYSTEM	SMACNA DUCT CONSTRUCTION STATIC PRESSURE CLASSIFICATION	SMACNA SEAL CLASSIFICATION	SMACNA LEAKAGE CLASSIFICATION	DUCT MATERIAL	REMARKS
Constant Volume Supply Ducts from Fan Discharge to Terminal Box	+3" WG	A	4(2)	Galvanized Sheet Metal	
Constant Volume Supply Ducts from Fan Discharge to Air Distribution Devices Risers	+2" WG +3" WG	A A	8(4) 4(2)	Galvanized Sheet Metal	See Field Quality Control sub-paragraph for leakage test requirement
Constant Volume Supply Ducts from Fan Discharge to Air Distribution Devices	+3" WG	A	4(2)	Galvanized Sheet Metal	Riser Testing
Fan Coil Units, Terminal Boxes, etc. Supply Ducts	+2" WG	A	8(4)	Galvanized Sheet Metal	See Field Quality Control sub-paragraph for leakage test requirement
Fan Coil Units, Terminal Boxes, etc. Return Ducts	-2" WG	A	8(4)	Galvanized Sheet Metal	See Field Quality Control sub-paragraph for leakage test requirement

DUCT SCHEDULE					
DUCT SYSTEM	SMACNA DUCT CONSTRUCTION STATIC PRESSURE CLASSIFICATION	SMACNA SEAL CLASSIFICATION	SMACNA LEAKAGE CLASSIFICATION	DUCT MATERIAL	REMARKS
Return Ducts connected to Air Handling Units or Return Air Fans	-2" WG	A	8(4)	Galvanized Sheet Metal	See Field Quality Control sub-paragraph for leakage test requirement
Riser Duct	-3" WG	A	4(2)		
Return Ducts from Terminal Boxes to Air Handling Units or Return Air Fans	-3" WG	A	4(2)	Galvanized Sheet Metal	Riser Testing
Exhaust Ducts connected to Exhaust Fans	-2" WG	A	8(4)	Galvanized Sheet Metal	See Field Quality Control sub-paragraph for leakage test requirements
Dryer & Toilets Exhaust System (Brach Ducts)	-2" WG	A	8(4)	Galvanized Sheet Metal Aluminum	Duct leakage Test required for this system

D. Intermediate Reinforcement:

1. Galvanized-Steel Ducts.

2. Stainless-Steel Ducts:

   a. Exposed to Airstream: Match duct material.

   b. Not Exposed to Airstream: Match duct material.

3. Aluminum Ducts: Aluminum radius type elbow RE-1 or RE-3 shall be used in lieu of mitered RE-2 except where physical constraints do not permit radius type elbow.

E. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 700 fpm (3.5 m/s) or Lower:

(1) Radius Type RE 1 with minimum 0.5 radius-to-duct width ratio.

(2) Square Throat Elbow Type RE 4 without vanes.

b. Velocity 700 fpm to 1500 fpm (3.5 to 7.6 m/s):

(1) Radius Type RE 3 with minimum 1.0 radius-to-duct width ratio and two vanes.

(2) Square Throat Elbow Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1500 fpm (7.6 m/s) or Higher:

(1) Radius Type RE 1 with minimum 1.5 radius-to-duct width ratio.

(2) Radius Type RE 3 with minimum 1.0 radius-to-duct width ratio and two vanes.

(3) Square Throat Elbow Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

(1) Velocity 1000 fpm (5 m/s) or Lower: 0.6 radius-to-diameter ratio and three segments for 90-degree elbow.

(2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.

(3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.

b. Round Elbows, 12 Inches (305 mm) and Smaller in Diameter: Stamped or pleated.

c. Round Elbows, 14 Inches (356 mm) and Larger in Diameter: Standing seam

F. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

   a. Rectangular Main to Rectangular Branch: 45-degree entry.

   b. Rectangular Main to Round Branch: Spin in.

2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

   a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.

   b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.

   c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION 23 31 13

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SECTION 23 33 00 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Flange connectors.
4. Duct silencers.
5. Turning vanes.
6. Remote damper operators.
7. Duct-mounted access doors.
8. Flexible connectors.
9. Flexible ducts.
10. Duct accessory hardware.

B. Related Requirements:

1. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

2. Product Data for Prerequisite EA 2: Documentation indicating that duct insulation R-values comply with tables in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning."

C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.

b. Manual volume damper installations.

c. Control-damper installations.

d. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90 (Z275).

2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts No. 4 and finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221 (ASTM B 221M), Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS AND COUNTERBALANCE BACKDRAFT DAMPER

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Air Balance Inc.; a division of Mestek, Inc.
2. American Warming and Ventilating; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. Lloyd Industries, Inc.
6. Nailor Industries Inc.
7. NCA Manufacturing, Inc.
8. Pottorff.
9. Ruskin Company.
10. Vent Products Company, Inc.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 2000 fpm (10 m/s).

D. Maximum System Pressure: 1-inch wg (0.25 kPa) 2-inch wg (0.5 kPa).

E. Frame: Hat-shaped, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel or 0.063-inch- (1.6-mm-) thick extruded aluminum, with welded corners or mechanically attachedand mounting flange.

F. Blades: Multiple single-piece blades, maximum 6-inch (150-mm) width, 0.025-inch- (0.6-mm-) thick, roll-formed aluminum with sealed edges or 28 gauge roll-formed galvanized steel. Dampers located in perimeter walls or fans located outdoors shall be aluminum construction.

G. Blade Action: Parallel.

H. Blade Seals: Extruded vinyl, mechanically locked.

I. Blade Axles:

1. Material: Galvanized steel, Stainless steel or Aluminum.

J. Tie Bars and Brackets: Aluminum or Galvanized steel.

K. Return Spring: Adjustable tension.

L. Bearings: Synthetic pivot bushings.

M. Accessories:

1. Adjustment device to permit setting for varying differential static pressure (for pressure relief dampers only).

2. Counterweights and spring-assist kits for vertical airflow installations.

3. Screen Mounting: Rear mounted.

4. Screen Material: Aluminum (For dampers mounted in perimeter walls only).

5. Screen Type: Insect.

6. 90-degree stops.

7. Mounting: Dampers shall be suitable for horizontal air (up/down) flow and vertical air flow.

N. For dampers located at fan discharge, mount dampers a minimum of one half fan diameter downstream of fan discharge.

O. Counterbalanced backdraft dampers shall be as described above except that damper blades shall be equipped with adjustable weights mechanically attached to blades.

2.4 MANUAL VOLUME DAMPERS

A. At the Contractor's option, shop fabricated manual volume damper maybe used in lieu of manufactured manual volume dampers. Manual volume damper shall be constructed in accordance with the requirements in SMACNA HVAC Duct Construction Standards – Metal and Flexible Manual Chapter 7. Where Contact Drawing designated "low leakage manual volume dampers", only test and rated manufactured dampers shall be used.

B. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Air Balance Inc.; a division of Mestek, Inc.

   b. American Warming and Ventilating; a division of Mestek, Inc.

   c. Flexmaster U.S.A., Inc.

   d. McGill AirFlow LLC.

   e. Nailor Industries Inc.

   f. Pottorff.

   g. Ruskin Company.

   h. Trox USA Inc.

   i. Vent Products Company, Inc.

2. Standard leakage rating.

3. Suitable for horizontal or vertical applications.

4. Frames:

   a. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel or 0.05-inch- (1.3-mm-) thick stainless steel.

   b. Material shall be compatible with duct construction (galvanized, stainless or aluminum).

   c. Mitered and welded corners.

   d. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

   a. Multiple or single blade.

   b. Parallel- or opposed-blade design.

   c. Stiffen damper blades for stability.

   d. Galvanized or Stainless-steel, 0.064 inch (1.62 mm) thick. Material shall be compatible with duct construction (galvanized, stainless or aluminum).

   e. Blade Axles: Galvanized steel or Stainless steel. Material shall be compatible with duct construction (galvanized, stainless or aluminum).

6. Bearings:

   a. Molded synthetic or Stainless Steel sleeve.

   b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

7. Tie Bars and Brackets: Galvanized steel or stainless steel. Material shall be compatible with duct construction (galvanized, stainless or aluminum).

8. Each damper shall include a locking device to hold damper in fixed (balanced) position without vibration.

9. Dampers in insulated duct systems shall include elevated duct platform suitable for insulated ducts.

C. Standard, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Air Balance Inc.; a division of Mestek, Inc.

   b. American Warming and Ventilating; a division of Mestek, Inc.

   c. McGill AirFlow LLC.

   d. Nailor Industries Inc.

   e. Pottorff.

   f. Ruskin Company.

   g. Trox USA Inc.

   h. Vent Products Company, Inc.

2. Standard leakage rating.

3. Suitable for horizontal or vertical applications.

4. Frames: Hat-shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

   a. Multiple or single blade.

   b. Parallel- or opposed-blade design.

   c. Stiffen damper blades for stability.

d. Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.

e. Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.

6. Blade Axles: Nonferrous metal.

7. Bearings:

a. Molded synthetic or Stainless-steel sleeve.

b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Aluminum.

9. Each damper shall include a locking device to hold damper in fixed (balanced) position without vibration.

10. Dampers in insulated duct systems shall include elevated duct platform suitable for insulated ducts.

D. Low-Leakage, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Air Balance Inc.; a division of Mestek, Inc.

b. American Warming and Ventilating; a division of Mestek, Inc.

c. McGill AirFlow LLC.

d. Nailor Industries Inc.

e. Pottorff.

f. Ruskin Company.

g. Trox USA Inc.

h. Vent Products Company, Inc.

2. Comply with AMCA 500-D testing for damper rating.

3. Low-leakage rating and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

4. Suitable for horizontal or vertical applications.

5. Frames:

a. Hat or U shaped.

b. 0.094-inch- (2.4-mm-) thick, galvanized sheet steel 0.05-inch- (1.3-mm-) thick stainless steel. Material shall be compatible with duct construction (galvanized, stainless or aluminum).

c. Mitered and welded corners.

d. Flanges for attaching to walls and flangeless frames for installing in ducts.

6. Blades:

a. Multiple or single blade.

b. Parallel- or opposed-blade design.

c. Stiffen damper blades for stability.

d. Galvanized or Stainless, roll-formed steel, 0.064 inch (1.62 mm) thick. Material shall be compatible with duct construction (galvanized, stainless or aluminum).

7. Blade Axles: Galvanized steel or Stainless steel. Material shall be compatible with duct construction (galvanized, stainless or aluminum).

8. Bearings:

a. Molded synthetic or Stainless-steel sleeve.

b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

9. Blade Seals: Neoprene.

10. Jamb Seals: Cambered. Material shall be compatible with duct construction (galvanized, stainless or aluminum).

11. Tie Bars and Brackets: Galvanized steel or Stainless Steel. Material shall be compatible with duct construction (galvanized, stainless or aluminum).

12. Accessories:

a. Include locking device to hold damper in a fixed (balanced) position without vibration.

b. Dampers in insulated duct systems shall include elevated duct platform suitable for insulated ducts.

E. Low-Leakage, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Air Balance Inc.; a division of Mestek, Inc.

b. American Warming and Ventilating; a division of Mestek, Inc.

c. McGill AirFlow LLC.

d. Nailor Industries Inc.

e. Pottorff.

f. Ruskin Company.

g. Trox USA Inc.

h. Vent Products Company, Inc.

2. Comply with AMCA 500-D testing for damper rating.

3. Low-leakage rating and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

4. Suitable for horizontal or vertical applications.

5. Frames: Hat or U shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.

6. Blades:

   a. Multiple or single blade.

   b. Parallel- or opposed-blade design.

   c. Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.

   d. Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.

7. Blade Axles: Nonferrous metal.

8. Bearings:

   a. Molded synthetic.

   b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

9. Blade Seals: Neoprene.

10. Jamb Seals: Cambered. Material shall be compatible with duct construction (galvanized, stainless or aluminum).

11. Tie Bars and Brackets: Aluminum.

12. Accessories:

    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

F. Jackshaft:

1. Size: 0.5-inch (13-mm) 1-inch (25-mm) diameter.

2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.

3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

G. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut.

2. Include center hole to suit damper operating-rod size.

3. Include elevated platform for insulated duct mounting.

2.5 FLANGE CONNECTORS (IF REQUIRED)

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Ductmate Industries, Inc.

2. Nexus PDQ; Division of Shilco Holdings Inc.

3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

C. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

D. Material: Galvanized steel.

E. Gage and Shape: Match connecting ductwork.

2.6 DUCT SILENCERS (IF REQUIRED)

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Dynasonics.
2. Industrial Noise Control, Inc.
3. McGill AirFlow LLC.
4. Ruskin Company.
5. Vibro-Acoustics.
6. Industrial Acoustic Company (IAC) America.

C. General Requirements:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
4. Duct silencers shall be constructed not to structurally fail when subject to a differential pressure of 6 inches Water Gauge from inside to outside casing. Where duct systems with duct pressure classification as specified in Section 23 31 13 titled Metal Ducts exceeds 6 inches, duct silencers shall be designed not to structurally fail when subject to a differential pressure equal to the duct pressure classification of the system.

D. Shape:

1. Rectangular straight with splitters or baffles.
2. Round straight with center bodies or pods.
3. Rectangular elbow with splitters or baffles.
4. Round elbow with center bodies or pods.
5. Rectangular transitional with splitters or baffles.

E. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90 (Z275), galvanized sheet steel, 0.034 inch (0.85 mm) 0.040 inch (1.02 mm) thick. Materials for construction of duct silencers mounted in aluminum or stainless steel duct systems shall be of the same materials as duct system and equivalent thickness.

F. Round Silencer Outer Casing: ASTM A 653/A 653M, G90 (Z275), galvanized sheet steel. Materials for construction of duct silencers mounted in aluminum or stainless steel duct systems shall be of the same materials as duct system and equivalent thickness.

1. Sheet Metal Thickness for Units up to 24 Inches (600 mm) in Diameter: 0.034 inch (0.85 mm) thick.

2. Sheet Metal Thickness for Units 26 through 40 Inches (660 through 1000 mm) in Diameter: 0.040 inch (1.02 mm) thick.

3. Sheet Metal Thickness for Units 42 through 52 Inches (1060 through 1300 mm) in Diameter: 0.05 inch (1.3 mm) thick.

4. Sheet Metal Thickness for Units 54 through 60 Inches (1370 through 1500 mm) in Diameter: 0.064 inch (1.62 mm) thick.

G. Inner Casing and Baffles: ASTM A 653/A 653M, G90 (Z275) galvanized sheet metal, 0.034 inch (0.85 mm) thick, and with 1/8-inch- (3-mm-) diameter perforations. Materials for construction of duct silencers mounted in aluminum or stainless steel duct systems shall be of the same materials as duct system and equivalent thickness.

H. Special Construction:

1. Suitable for outdoor use.

2. High transmission loss to achieve STC 45.

I. Connection Sizes: Match connecting ductwork unless otherwise indicated.

J. Principal Sound-Absorbing Mechanism:

1. Controlled impedance membranes and broadly tuned resonators without absorptive media where drawings call for Packless Duct Silencers.

2. Dissipative,Film-lined type with fill material.

a. Fill Material: Inert, vermin-proof and moisture-proof fibrous material, packed under not less than 5 percent compression.

b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.

3. Lining: None OR Tedlar.

K. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Joints: flanged connections.

2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.

3. Reinforcement: Cross or trapeze angles for rigid suspension.

L. Accessories:

1. Factory-installed end caps to prevent contamination during shipping.

2. Removable splitters.

M. Source Quality Control: Test according to ASTM E 477.

1. Testing of mockups to be witnessed by Owner.

2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm (10-m/s) face velocity.

3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg (1500-Pa) static pressure, whichever is greater.

N. Capacities and Characteristics:

1. See Duct Silencer (Sound Attenuator) schedule on drawings for capacities and characteristics

2.7 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Ductmate Industries, Inc.

2. Duro Dyne Inc.

3. Elgen Manufacturing.

4. METALAIRE, Inc.

5. SEMCO Incorporated.

6. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

E. Vane Construction: Single wall construction with a 4½ Inches (114 mm) radius and spaced at 3¼ Inches (83 mm) as defined in SMACNA. Double wall construction with a 4½ Inches (114 mm) radius and spaced 3¼ Inches (83 mm) as defined in SMACNA. Turning vanes shall be welded to runners. Runners for turning vanes shall be secured to the duct so that they do not generate noise or vibration. Runners for turning vanes in duct where the duct velocity exceeds 1,500 FPM, runner welded to the duct.

F. Vane Construction: Single walled turning vanes shall be used in all ducts with velocities or 2.300 FPM or less. Double walled turning vanes shall be used in all duct system with duct velocity in excess of 2,200 FPM. Construction for turning vanes shall be as defined in SMACNA's HVAC Duct Construction Standards – Metal and Flexible Chapter 4 except that the maximum unsupported length for single thickness shall be 24 Inches (605 mm) and a maximum unsupported length for double thickness shall be 30 Inches (755 mm).

2.8 REMOTE DAMPER OPERATORS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Pottorff.

2. Ventfabrics, Inc.

3. Young Regulator Company.

B. Description: Cable system designed for remote manual damper adjustment.

C. Tubing: Brass, Copper or Aluminum.

D. Cable: Stainless steel.

E. Wall-Box Mounting: Recessed.

F. Wall-Box Cover-Plate Material: Stainless steel.

2.9 DUCT-MOUNTED ACCESS DOORS

A. At the Contractor's option, shop fabricated access doors maybe used in lieu of manufactured access doors. Access doors shall be constructed in accordance with the requirements in SMACNA HVAC Duct Construction Standards – Metal and Flexible Manual Chapter 7. Where Contact Drawing designated "pressure relief access doors, only test and rated manufactured access doors shall be used.Manufacturers: Subject to compliance with requirements, provide products by the following:

1. American Warming and Ventilating; a division of Mestek, Inc.

2. Cesco Products; a division of Mestek, Inc.

3. Ductmate Industries, Inc.

4. Elgen Manufacturing.

5. Flexmaster U.S.A., Inc.

6. Greenheck Fan Corporation.

7. McGill AirFlow LLC.

8. Nailor Industries Inc.

9. Pottorff.

10. Ventfabrics, Inc.

11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

C. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

a. Double wall, rectangular.

b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.

c. Vision panel. (24 x 48 inch and large access doors only)

d. Hinges and Latches: 1-by-1-inch (25-by-25-mm)butt or piano hinge and cam latches.

e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

3. Number of Hinges and Locks:

a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.

b. Access Doors up to 18 Inches (460 mm) Square: Two hinges, Continuous, and two sash locks.

c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges, Continuous, and two compression latches with outside and inside handles.

d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges, Continuous, and two compression latches with outside and inside handles.

2.10 DUCT ACCESS PANEL ASSEMBLIES (IF REQUIRED)

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Ductmate Industries, Inc.

2. Flame Gard, Inc.

3. 3M.

C. Labeled according to UL 1978 by an NRTL.

D. Panel and Frame: Minimum thickness 0.060-inch (1.5-mm) Stainless Steel (thickness equivalent to carbon steel for duct pressure class).

E. Fasteners: Stainless steel. Panel fasteners shall not penetrate duct wall.

F. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F (1093 deg C).

G. Minimum Pressure Rating: 10-inch wg (2500 Pa), positive or negative.

2.11 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Ductmate Industries, Inc.

2. Duro Dyne Inc.

3. Elgen Manufacturing.

4. Ventfabrics, Inc.

5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 12 inches (300 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).

2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.

3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).

2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.

3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).

G. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.

2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.

7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.

2.12 FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Flexmaster U.S.A., Inc.

2. McGill AirFlow LLC.

3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Insulated Flexible Duct with Vapor Barrier

1. UL 181, Class 1

2. Mechanical interlocking spiral aluminum with circumferential corrugation for strength and flexibility (adhesives not permitted)

3. Fibrous-glass insulation with a minimum thermal resistance (R) equal to 8

4. Factory applied vapor barrier with a permeance of 0.05 Perms (ASTM E 96-66 Procedure A)

5. Flame/Smoke 25/50

6. Maximum Duct Velocity 5,500 FPM

7. Pressure rating Positive 10" w.g. through 16" diameter, 6" w.g. 18" & 20"; Negative 12" w.g. through 16" diameter, 4" w.g. 18" & 20" diameter

8. Minimum bend diameter 1.5 duct diameter.

C. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 20 inches (75 through 500 mm), to suit duct size.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft and control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. If the location of manual balancing damper is not defined on the drawing the following minimum standards for supply, return and exhaust shall govern:

1. Main ducts from trunk ducts

2. Branch ducts from main ducts

3. Sub-branch ducts from branch ducts

4. Sub-sub branch ducts from sub-branch.

5. Locate dampers as far as possible from air outlets to avoid noise transmission.

E. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.
3. Install stainless steel volume dampers in stainless steel ducts.

F. Set dampers to fully open position before testing, adjusting, and balancing.

G. Install test holes at fan inlets and outlets and elsewhere as indicated.

H. Connect ducts to duct silencers rigidly.

I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream and downstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from control dampers, backdraft dampers, and equipment.
6. At each change in direction and at maximum 50-foot (15-m) spacing.
7. Upstream and downstream from turning vanes.
8. Upstream or downstream from duct silencers.
9. Control devices requiring inspection.
10. Upstream and downstream of air flow stations
11. Upstream and/or downstream of equipment requiring of equipment service.
12. Sheet metal plenums (two required on opposite sides of plenum.

J. Install access doors with swing against duct static pressure.

K. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
3. Head and Hand Access: 24 by 10 inches (600 by 250 mm).
4. Head and Shoulders Access: 24 by 14 inches (600 by 355 mm).

5. Body Access: 24 by 48 inches (600 by 1200 mm).

L. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

M. Install flexible connectors to connect ducts to equipment.

N. Connect terminal units to supply ducts directly or with maximum 12-inch (300-mm) lengths of flexible duct. Do not use flexible ducts to change directions.

O. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch (1500-mm) lengths of flexible duct clamped in place. If the length of flexible duct (60 inches) exceeds allowable length by local jurisdiction, local jurisdiction governs.

P. Connect flexible ducts to metal ducts with clamps as described in a previous paragraph in this section.

Q. Install duct test holes where required for testing and balancing purposes.

R. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop of fans.

3.2 CONTROL DAMPERS

A. Control dampers will be furnished as part of the work Section of this specification. This Contractor shall install Control Dampers.

B. Coordinate with Control Contractor size and location of control dampers.

3.3 FLEXIBLE CONNECTIONS

A. All fan and air supply unit connections, both at inlet and discharge shall be made with flexible material so as to prohibit the transfer of vibration from fans to ductwork connecting thereto, without air leakage. The material between the clamps shall have sufficient slack so as to prevent tearing due to fan movement.

B. The flexible connections shall be a minimum of 12" long and held in place with heavy metal bands, securely attached, to prevent any leakage at the connection points.

C. Flexible connections shall be fabricated from approved flame proofed fabric conforming to 90A of the N.F.P.A. Asbestos cloth is not permitted.

DAMPER (CONTROL, SMOKE & FIRE/SMOKE) ASSIGNMENT SCHEDULE					
SYSTEM COMPONENTS	FURNISHED BY	INSTALLED BY	POWER CONTROL WIRING BY	CONTROL WIRING BY	REMARKS
Control Dampers required as part of an HVAC System	Controls Contractor	HVAC Contractor	Controls Contractor	Controls Contractor	Actuators provided by Controls Contractor

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.

2. Inspect locations of access doors and verify that purpose of access door can be performed.

3. Inspect turning vanes for proper and secure installation.

4. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 23 33 00

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SECTION 23 34 23 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Utility set fans.
2. Ceiling-mounted ventilators.
3. In-line centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on sea level for projects at elevations 1,000 feet or lower.

B. Operating Limits: Classify according to AMCA 99.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Roof curbs.
7. Fan speed controllers.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Design Calculations: Calculate requirements for selecting vibration isolatorsand for designing vibration isolation bases.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Roof framing and support members relative to duct penetrations.
2. Ceiling suspension assembly members.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set(s) for each belt-driven unit.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. UL Standards: Power ventilators shall comply with UL 705.

1.9 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 FANS - GENERAL

A. Fans shall be of the types and capacities listed in the Schedules on the Contract Documents and as specified herein.

B. Fan performance shall be based on tests conducted in accordance with ASHRAE 51 and AMCA Standard Test Code for Centrifugal and Axial Fans and fans shall bear the AMCA Certified Ratings Seal for Sound and Air Performance.

C. Fan shall be listed by Underwriters Laboratories (UL/cUL 705) for US and Canada.

D. Centrifugal fans to be non-over-loading having a sharply rising pressure characteristic which will extend throughout the operating range and continue to rise well beyond the efficiency peak to ensure quiet, stable operation under all conditions. The horsepower characteristic shall be truly self-limiting and shall reach a peak in the normal selection area. Unit shall be of manufacture as noted on drawings, or approved. Submit sound power ratings for approval.

E. Fans shall be provided with mechanical brake, coordinate with BMS.

F. Fans shall be statically and dynamically balanced at the factory prior to shipment. Fans shall be balanced for inverter duty operation (VFC). The fan will be balanced over the entire range of fan operation (30% to 100% of RPM). Filter-in measurements shall not exceed 5 mils in the horizontal and vertical planes. Filter-out measurements shall not exceed 7.5 mils in the horizontal, vertical and axial planes. The maximum allowable RMS velocity at maximum fan class speed measured at each bearing shall not exceed 0.09 inches/sec. All fans 10,000 CFM and larger shall have factory balancing certified in writing. Certification shall be submitted prior to shipment of fans.

G. Fan shall be minimum Class I construction with proper UL label. Fan Class shall be as scheduled on the drawings.

H. The specified fan RPM, outlet velocity, and trip speed are the maximum acceptable. The motor horsepower, CFM, and static pressure are the minimum acceptable.

I. Unless noted otherwise by specific fan type housing, fan housing shall be heavy gauge continuous welded steel construction with fan scroll and bearings supported from structural steel framework.

J. Fan housing shall be of suitable thickness and bracing required for stable and rigid construction, with no deflection, and to prevent vibration and pulsation.

K. Provide inlet screens for all fans, constructed for easy removal, manufacturer of heavy wire mesh.

L. Fans having duct-connected inlets shall be provided with a flanged inlet and/or outlet collar matching companion flange.

M. For exterior mounted fans, a weatherproof housing shall be provided with ventilation grilles to cover motor and drive assembly.

N. Provide birdscreen on fans exposed to the environment.

O. Provide adequate space for service of fan, motor and bearings.

P. The fan shaft shall be solid steel, accurately turned, ground and polished, and ring gauged for accuracy.

Q. Recommended bearing manufacturer tolerances must be met in the contact area for bearings.

R. Shafts must be dial indicator inspected for straightness after the keys are cut.

S. Fan shaft shall be coated with rust inhibitive coating.

T. Fan wheel assembly or propeller assembly shall be statically and dynamically balanced prior to fan assembly.

U. The entire rotating assembly shall be designed so the first critical speed is a minimum of 25% greater than the max class fan speed.

V. Fan Shaft Bearings/Sheave

1. Fan bearings shall be foot-mounted type, bolted on a rigid welded steel framework integral with the housing.
2. Bearings shall be designed and individually tested specifically for use in air handling applications.
3. Bearings shall be sized for a minimum L-10 life of 200,000 hours at maximum fan class operating conditions including belt pull, unless noted otherwise. Bearings shall be selected in accordance with standards set forth by the Anti-Friction Bearing Mfrs. Assn. (AFBMA).
4. Bearings shall be double-row spherical, self-aligning, grease lubricated, roller bearings housed in a horizontally split pillow block housing.
5. Where bearings are not easily accessible or motor is installed in airstream, provide stable, accessible clear plastic grease leads to a common location.
6. Fan sheave shall be of the non-adjustable type and machined on all surfaces Fan sheave shall be statically and dynamically balanced. If weights are required for balancing, weights shall be welded to sheave. Fan sheave shall have tapered lock, split and keyed to hub.
7. Replacement Fan sheaves: provide additional fan sheaves as required for balancing at no additional cost to the owner.

W. Fan Motor and Drive

1. Motors shall meet requirements as specified under another section of Division 23 work titled "Common Motor Requirements for HVAC Equipment".
2. Fan drive shall be a multiple V-belt type sized for 1.65 times the fan motor horsepower, unless noted otherwise.
3. Provide balanced variable sheaves for motors 60 HP and under. Size variable sheaves at midpoint of specified operating conditions to allow field adjustment up or down during balancing procedures.

4. V-Belt Drives: The fans are to be driven with V-belt drive, of ample capacity sized for 1.65 x motor HP. Motor sheaves shall be adjustable ratio type; they shall be sized to give the required fan speed with motor sheave at about the middle of its range of adjustment. Motor sheave adjustment range shall be selected for the rated fan RPM as determined by fan capacity requirements scheduled on the drawings and adjustable to fifteen (15%) percent above and below the rated fan speed. There shall be at least two (2) belts; and drive capable of carrying the entire load with an additional 50% safety factor. Belt guards with opening for RPM readings to be provided for all sheaves and belts. Submit drive data for approval. If the fan capacity with scheduled fan speed is below design, change sheave and adjust as required to meet design capacity.
5. Some fans will be furnished with ECMs as indicated in the Contract Documents. T
6. Each motor for a belt driven fan shall be factory mounted on an adjustable base rigidly supported on the fan and shall have extended shaft to accommodate the adjustable pitch sheaves.
7. Motor shall be 1800 rpm maximum for belt driven or direct drive fans.
8. An OSHA approved type fan drive belt guard shall be provided with provision for RPM measurement at both motor and fan without removing the guard. The guard shall be made of ½" 16 gauge flattened expanded steel, wrapped around a 16 gauge channel frame suitably braced to prevent vibration. Guard shall be G-90 galvanized with coating same as fan.
9. Fan belts shall be oil resistant 24,000 hour non-sparking, non-static belts. For fans ½ HP and larger, quantity of belts shall be such that if one belt fails, remaining belts shall allow for fan to continue to functioning as designed.

X. Sound Rating:

1. Fan sound ratings shall be based on AMCA 300 tests in a sound laboratory reverberant room. Data must be based on RSS calibration within last six (6) months. Separate data must be provided for both inlet and outlet.
2. Where the manufacturer's sound power data is not published, an officer of the company must certify that sound data conforms with the requirements specified under another section of this work. If the manufacturer does not have acoustical facilities in accordance with the above requirements, the contractor must submit certified data that the specified units have been tested in an approved independent acoustics lab, capable of testing equipment at specified operating conditions to determine sound power levels by octave band.

3. Where units do not meet the above requirements, the Subcontractor must furnish at no additional cost, necessary attenuation to reduce net sound level to the above requirements. In this case, the room sound level must be taken by the Subcontractor and submitted for approval by the Engineer to assure conformance to sound level requirements.
4. The increase pressure drop due to attenuation must not cause and increase in power requirements from those specified. If oversized, slow speed fan is required, this Contractor shall be responsible for any related extra costs from other trades to accommodate change in fan.

Y. Provide thrust arrestors as required to limit movement of the fan upon start-up.

Z. Manufacturer shall provide heavy gauge windband constructed of bolted steel with reinforced edges and bolted seams and butterfly damper constructed of heavy gauge aluminum with field-replaceable neoprene seals, as required.

AA. Provide riveted, engraved aluminum nameplate containing pertinent, specific fan data, including manufacturer, model, serial number, etc.

BB. Roof mounted fans and fans exposed to the weather shall have all fan parts clean and prime painted prior to final assembly. Fan wheels and housing shall be provided with two coats of corrosion resistance epoxy paint after final assembly.

2.2 UTILITY SET FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Aerovent; a division of Twin City Fan Companies, Ltd.
2. Loren Cook Company.
3. Greenheck Fan Co..

B. Housing: Fabricated of galvanized steel with side sheets fastened with a deep lock seam or welded to scroll sheets.

1. Housing Discharge Arrangement: Adjustable to eight standard positions.
2. Fan type AMCA arrangement 10 with a single width and single inlet housing.
3. Housing and bearing supports shall be constructed of welded steel members to prevent vibration and to rigidly support the shaft and bearing assembly
4. Housing support constructed of structural steel with formed flanges
5. Drive frame is welded steel that supports the shaft and bearing and reinforcement for the housing
6. Pivoting motor plate with adjusting screws for belt tensioning.
7. Finish as described in previous sub-paragraph titled “Fans – General” above.

C. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.

1. Blade Materials: Steel or Aluminum.
2. Blade Type: Backward inclined or Airfoil as scheduled on drawings.

3. Non-overloading centrifugal wheel; rotation as determined by layout on drawings
4. Single thickness blades securely riveted or welded to heavy gauge blackplate and wheel cone
5. Wheel cone and fan inlet matched and shall have close running tolerances for maximum performance and operating efficiency
6. Statically and dynamically balanced in accordance with AMCA Standard 204-05
7. Spark-Resistant Construction: AMCA 99, Type as scheduled on drawings.

D. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

1. Fan Pulley: For requirements, see previous sub-paragraph titled "Fan – General above

E. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L_{10} of 80,000 hours.

1. Extend grease fitting to accessible location outside of unit.

F. Belt Drives:

1. Factory mounted, with final alignment and belt adjustment made after installation
2. Motor Pulleys: For requirements, see previous sub-paragraph titled "Fans – General" above.
3. Belts: For requirements, see previous sub-paragraph titled "Fans – General" above.
4. Belt Guards: For requirements, see previous sub-paragraph titled "Fans – General" above.

G. For motor requirements see Division 23 Section titled "Common Motor Requirements for HVAC Equipment"

H. Accessories:

1. Inlet and Outlet: Flanged.
2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
3. ALD's
4. Access Door: Gasketed door in scroll with latch-type handles.
5. Inlet Screens: Removable wire mesh.
6. Drain Connections: NPS 3/4 (DN 20) threaded coupling drain connection installed at lowest point of housing with drain valve.
7. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
8. Discharge Dampers: Assembly with parallel blades constructed of two plates formed around and to shaft, channel frame, sealed ball bearings, with blades linked outside of airstream to single control lever of same material as housing.
9. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
10. Heat Slinger to dissipate heat along fan shaft
11. Shaft seal on rub ring to seal shaft

I. Capacities and Characteristics:

1. See schedule on drawings for fan requirements.

2.3 CEILING-MOUNTED VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Greenheck Fan Corporation.
2. Loren Cook Company.

B. Housing: Steel, lined with acoustical insulation.

C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

D. Grille: Aluminum, louvered grille with flange on intake and thumbscrew attachment to fan housing.

E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
4. Motion Sensor: Motion detector with adjustable shutoff timer.
5. Filter: Washable aluminum to fit between fan and grille.
6. Isolation: Rubber-in-shear vibration isolators.
7. Manufacturer's standard roof jack or wall cap, and transition fittings.

G. Capacities and Characteristics:

1. See schedule on drawings for fan requirements.

2.4 IN-LINE CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Greenheck Fan Corporation.
2. Loren Cook Company.

B. General Description:

1. Base fan performance at standard conditions (density 0.075 Lb/ft3).
2. Each fan shall bear a permanently affixed manufacture's engraved metal nameplate containing the model number and individual serial number.
3. Fan design for straight thru flow.

C. Wheel:

1. Non-overloading, backward inclined centrifugal wheel.
2. Constructed of aluminum.
3. Satically and dynamically balanced in accordance to AMCA Standard 204-05.
4. The wheel cone and fan inlet will be matched and shall have precise running tolerances for maximum performance and operating efficiency.
5. Single thickness blades are securely riveted or welded to a heavy gauge back plate and wheel cone.
6. Direct drive fan wheel direct connected to motor.

D. Motors:

1. Motor: For motor requirements, see Division 23 Section titled "Common motor Requirements for HVAC Equipment.
2. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.
3. Totally enclosed air over (TEAO) Totally enclosed fan cooled (TEAC).

E. Shafts and Bearings:

1. Fan shaft shall be ground and polished solid steel with an anti corrosive coating.
2. Permanently sealed bearings or pillow block ball bearings.
3. Bearing shall be selected for a minimum L10 life in excess of 100,000 hours (equivalent to L50 average life of 500,000 hours), at maximum cataloged operating speed.
4. Fan Shaft first critical speed is at least 25 percent over maximum operating speed.

F. Housing/Cabinet Construction

1. Square design constructed of heavy gauge galvanized steel and shall include square duct mounting collars
2. Housing and bearing supports shall be constructed of heavy gauge bolted and welded steel construction to prevent vibration and to rigidly support the shaft and bearing assembly.

G. Housing Supports and Drive Frame:

1. Housing supports are constructed of structural steel with formed flanges.
2. Drive frame is welded steel which supports the shaft and bearings and reinforcement for the housing.
3. Pivoting motor plate with adjusting screws to make belt tensioning operations.

H. Disconnect Switches:
1. NEMA rated: 1 3R
2. Positive electrical shut-off.
3. Wired from fan motor to junction box installed within motor compartment.
4. Nonfusible type with thermal overload protection mounted on the fan housing.

I. Drive Assembly:

1. Belts, pulleys, and keys oversized for a minimum of 150 percent of driven horsepower. For requirements, see previous sub-paragraph titled "Fans – General" above.
2. Belts: Static free and oil resistant. For requirements, see previous sub-paragraph titled "Fans – General" above.
3. Pulleys: Cast type, keyed, and securely attached to wheel and motor shafts. For requirements, see previous sub-paragraph titled "Fans – General" above.
4. Motor pulleys are adjustable for final system balancing. For requirements, see previous sub-paragraph titled "Fans – General" above.
5. Readily accessible for maintenance.

J. Duct Collars:

1. Square design to provide a large discharge area.
2. Inlet and discharge collars provide easy duct connection.

K. Access Panel:

1. Two sided access panels, permit easy access to all internal components.
2. Located perpendicular to the motor mounting panel.

L. Accessories:

1. Belt Guards:

   a. For requirements, see previous sub-paragraph titled "Fans – General" above.

2. Dampers:

   a. Types: ALD's
   b. Galvanized frames with prepunched mounting holes.

3. Extended Lube Lines:

   a. Grease zerks on housing exterior allows for lubrication of bearings without disassembling the fan.

4. Finishes:

   a. Coating type: Manufacturer's standard coating.

5. Inlet and Outlet Guards:

   a. Constructed of expanded metal mounted in a steel frame to provide protection for non-ducted installations.

6. Insulated Housing

   a. Thickness: 1 inches.
   b. For acoustical liner requirements see Division 23 Section titled “Metal Ducts”.

7. Motor Cover:

   a. Constructed of galvanized steel.

8. Wiring Pigtail:

   a. Direct hook-up to the power supply.
   b. Nine foot wiring extension.

9. Companion Planges

   a. inlet and outlet duct connections.

10. Variable speed Controller (direct drive fans only).

11. Fan Housing aluminum construction in lieu of galvanized sheet metal.

M. Capacities and Characteristics:

1. See schedule on drawings for fan requirements.

N. Accessories:

1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
2. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
3. Wall Sleeve: Galvanized steel to match fan and accessory size.
4. Weathershield Hood: Galvanized steel to match fan and accessory size.
5. Weathershield Front Guard: Galvanized steel with expanded metal screen.
6. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
7. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

O. Capacities and Characteristics:

1. See schedule on drawings for fan requirements.

2.5 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 section titled, "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

B. Enclosure Type: Totally enclosed, fan cooled.

2.6 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using Vibration devices are specified in vibration section of Division 23.

1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounted units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

D. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Division 7, titled "Roof Accessories" for installation of roof curbs.

E. Support suspended units from structure using threaded steel rods and vibration-control devices are specified in vibration section of Division 23.

F. Install units with clearances for service and maintenance.

G. Label units according to requirements specified in Division 23 Section titled, "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23, Section titled, "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 26, Section titled "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26, Section titled "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. HVAC Contractor shall perform the following tests and inspections.

B. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Division 23, Section titled "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION 23 34 23

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SECTION 23 37 13 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Rectangular and square ceiling diffusers.

2. Linear bar diffusers.

3. Linear slot diffusers.

4. Adjustable bar registers and grilles.

5. Fixed face registers and grilles.

B. Related Sections:

1. Division 23; Section Titled "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 QUALITY ASSURANCE

A. Manufacturers Qualifications: Firms regularly engaged in manufacture of air distribution devices, air outlets and inlets of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. All air distribution equipment shall be designed, manufactured and tested in accordance with the latest applicable industry standards including the following:

1. AHRI Compliance: Test and rate air devices in accordance with AHRI Standards.

2. ANSI/ASHRAE Compliance: Test and rate air devices in accordance with ANSI/ASHRAE Standards.

3. ADC Seal: Provide devices bearing ADC Certified Rating Seal.

4. AMCA Compliance: Test and rate air devices in accordance with AMCA Standards and shall bear AMCA Certified Rating Seal.

5. NFPA Compliance: Install air devices in accordance with NFPA 90A Standard for the Installation of Air Conditioning and Ventilating Systems.

6. UL Compliance: The complete device must be labeled and listed by UL and must be installed to meet their requirements.

7. All devices must be tested and approved for safety in accordance with the latest N.E.C.

1.4 ACOUSTICAL SPECIFICATION FOR DIFFUSERS

A. Air Distribution System; Diffusers, Grilles and Register Noise: Maximum permissible sound power levels in octave bands of airborne transmission through the combination of grille, registers, diffusers, or related pressure reducing devices, when operated at the maximum inlet pressure and cfm in installed condition per plans and specifications shall be as follows:

Children Rooms	NC 35
Private Offices	NC 35
Conference Rooms	NC 35
Open Plan Offices	NC 40
Corridors	NC 40
Bathrooms	NC 45
Storage Rooms	NC 45
Kitchen	NC 50

AIR DISTRIBUTION SYSTEM EQUIPMENT/TERMINAL DEVICE NOISE
MAX PWL (dB re 10 12 Watt)

Octave Band	NC 35	NC 40	NC 45	NC 50+
1	62	66	68	70
2	56	60	63	66
3	49	54	58	62
4	46	51	56	61
5	43	48	53	58
6	42	47	52	57
7	41	46	51	56
8	42	47	52	57

1.5 ACTION SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for air outlets and inlets including the following:

1. Manufacturer's technical product data, including performance data for each size and type of air distribution device furnished; schedule showing drawing designation, room location, number furnished, model number, size and accessories furnished and installation and start-up instructions.

2. Data sheet for each type of air outlet and inlet, and accessory furnished, indicating construction, finish and mounting details.

3. Performance data for each type of air outlet and inlet furnished, including aspiration ability, temperature and velocity traverses, throw and drop, and noise criteria ratings. Indicate selections on data.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

C. Wiring Diagrams: Submit ladder-type wiring diagrams for electric power and control components, clearly indicating required field electrical connections.

D. Maintenance Data: Submit maintenance data and parts list for each type of air terminal, including trouble shooting maintenance guide. Include this data, product data, shop drawings, and maintenance data in maintenance manual, in accordance with requirements of Division 01.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.

2. Method of attaching hangers to building structure.

3. Size and location of initial access modules for acoustical tile.

4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

5. Duct access panels.

B. Source quality-control reports.

1.7 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver air distribution devices wrapped in factory-fabricated fiber-board type containers. Identify on outside of container type of device and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.

B. Store air outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors, when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 – PRODUCTS

2.1 DIFFUSERS, REGISTERS AND GRILLES

A. General

1. All grilles, registers, ceiling outlets and floor outlets shall be furnished and installed as shown on the contract documents and as specified herein.

2. All grilles, registers, ceiling outlets and floor outlets shall be similar and approved equal to the types indicated on the Drawings and specified herein

3. Devices shall be aluminum or steel and shall be factory finished with baked white enamel finish or extruded aluminum finish unless otherwise scheduled on the drawings.

4. Equipment manufacturer shall submit engineering data in a manner to facilitate convenient review of the following factors:

   a. Throw, terminal velocity, noise criteria (NC), sound power, static pressure and total pressure of each type and size of air outlet.

   b. Supply air units shall distribute the specified quantity of air evenly throughout the occupied zone uniformly, draftlessly and noiselessly. Sound levels shall not exceed ratings as required in the "Acoustical Treatment" section of these specifications.

   c. For devices installed in plaster construction, supply plaster frames as required for setting.

   d. All design and margin construction shall be coordinated with architectural requirements. Plaster frames where required shall be constructed of same material and finish as air terminal.

   e. The air outlet manufacturer shall review architectural plans and shall be responsible for furnishing all air outlets with frames and margins which will be compatible with ceiling construction.

5. All ceiling diffusers shall be furnished and installed with an equalizing deflector and volume damper.

6. If diffuser is to be used for return air, omit equalizing deflector.

7. Supply diffusers shall be gasketed to prevent streakage, unless installed in T-bar or concealed spline ceiling.

8. Blank-off or sectorizing baffles shall be furnished as indicated.

9. Diffusers shall be aluminum or steel and shall be factory finished with baked acrylic paint finish of color selected by Architect.

10. Diffusers shall be tested and certified in accordance with latest edition of ANSI/ASHRAE Standard 70

2.2 CEILING DIFFUSERS

A. Square Ceiling Diffusers. TITUS MODELS TMS & TMSA

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anemostat Products; a Mestek company.

   b. Carnes.

   c. Krueger.

   d. METALAIRE, Inc.

   e. Nailor Industries Inc.

   f. Price Industries.

   g. Titus.

   h. Tuttle & Bailey.

2. Material: Steel (24 Gauge), Aluminum (0.040 inches) as scheduled on the drawings

3. Finish: Baked acrylic paint; white for steel air distribution devices, anodized for aluminum or as scheduled on the drawings or other special finish as scheduled on drawings

4. Face Size

   a. Square;

      (i) 24 x 24 inches (600 x 600 mm) (Steel and Aluminum)

      (ii) 12 x 12 inches (300 x 300 mm) (Steel only)

5. Face Style: Three cones: One fixed cone; two adjustable cones (two adjustable cones shall include adjustable vanes to allow flow pattern from fully horizontal to fully vertical).

6. Mounting: per architect: Surface T-bar Snap in Spline Mounting panel.

7. Pattern: Fixedor Full Adjustable (Horizontal to Vertical).

8. Dampers: Radial blade.

9. Accessories:

   a. Equalizing grid.

   b. Plaster ring (where required for ceiling construction); See architectural drawings for ceiling construction).

   c. Safety chain.

   d. Sectorizing Baffles (where called for on drawings)

   e. Earthquaker Tabs (provide only if project in seismic zone)

B. Square Plaque <TITUS MODEL OMNI>

1. Manufacturers: Subject to compliance with requirements, provide produces by one of the following:

   a. Anemostat Produces; a Mestek company

   b. Carnes

   c. Krueger

   d. Metalaire, Inc.

   e. Nailor Industries Inc.

   f. Price Industries

   g. Titus

   h. Tuttle & Bailey

2. Devices shall be specifically designed for variable-air-volume flows

3. Material; Steel; 22 gauge Plaque face and Backpan; Aluminum heavy gauge with equivalent strength to steel for plaque face and backpan. Plaque panel shall have an aerodynamically shaped and rolled edge to ensure a tight to ceiling horizontal discharge pattern

4. Module Size:

   a. Steel; 12 x12 inches with a 9 x 9 inch plaque (minimum) and 24 x 24 inch with an 18 x 18 inch (minimum) plaque.

   b. Aluminum; 24 x 24 inch with an 18 x 18 inch plaque (minimum)

5. Face Style; Flat Plaque

6. Mounting; Surface, snap-in, T bar and spline; See architectural drawings for ceiling construction

7. Dampers; Radial blade

8. Accessories

   a. Equalizing Grid

   b. Sectorizing Baffles (where called for on drawings)

   c. Earthquaker Tabs (provide only if project in seismic zone)

   d. Insulated backpan

9. Finish; Standard Baked acrylic paint (white); (See drawings for scheduled finish or other special finish as scheduled on drawings.

2.3 LINEAR SLOT OUTLETS

A. Linear Bar Diffuser <TITUS MODELS CT-480, CT-580, & CT-540>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anemostat Products; a Mestek company.

   b. Carnes.

   c. Krueger.

   d. METALAIRE, Inc.

   e. Nailor Industries Inc.

   f. Price Industries.

   g. Titus.

   h. Tuttle & Bailey.

2. Devices shall be specifically designed for variable-air-volume flows.

3. Material; extruded aluminum bars and heavy gauge extruded aluminum frame/border.

   a. For floor applications, bars and frame/border shall be specifically designed for floor applications with a minimum of 200 pounds per square inch.

b. Bars for ceiling and sidewall diffusers shall be supported per manufacturers standard design but in no case shall the interval between supports exceed 9 feet maximum. Bars for floor diffusers shall be supported per manufacturers standard design but in no case shall the interval between supports exceed 6 feet maximum.

c. Bar support shall be parallel to the short dimension of diffuser.

d. Diffuser core shall be locked into frame/border.

4. Finish; Baked acrylic paint white, aluminum or clear anodized as scheduled on the drawings or other special finish as scheduled on drawings.

5. Core Spacing Arrangement; for core bar spacing, bar width and bar deflection, see Air Distribution Schedule on Drawings.

6. Frame/Border; See Air Distribution Device schedule for frame and border types.

7. Damper; adjustable opposed blade

8. Accessories;

a. Alignment strips and pins for continuous diffusers with multiple diffusers sections.

b. Blank-off strips where called for on drawings

c. For straight diffusers, provide extruded aluminum end borders to match at each end.

d. For diffusers that change direction, provide mitered joints at directional change.

e. Plaster frame; See architectural drawing for diffusers where construction requires this type frame

9. Where shown on drawing, diffuser shall be curved to radius called for on drawings. Minimum curvature radius 6 feet.

B. Linear Slot Diffuser <TITUS MODEL ML-37, ML-38, & ML-39>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anemostat Products; a Mestek company.

b. Carnes.

c. Hart & Cooley Inc.

d. Krueger.

e. METALAIRE, Inc.

f. Nailor Industries Inc.

g. Price Industries.

h. Titus.

i. Tuttle & Bailey.

2. Devices shall be specifically designed for variable-air-volume flows.

3. Material; Face and frame/border shall be heavy gauge extruded aluminum.

4. Pattern Controller; Aerodynamically curved "Ice-tong" shaped steel deflector with 180º pattern adjustment from the face. Maximum length of pattern controller 3 feet. For linear diffusers longer than three feet, multiple section of pattern controller shall be provided.

5. See Air Distribution Device schedule for frame and border types.

6. Finish; Baked acrylic paint, white or aluminum as scheduled on the drawings or other special finish as scheduled on drawings.

   a. Pattern controller shall be baked acrylic paint, black

7. Length; See drawing for linear diffuser required length. Linear diffuser shall be made up of multiple section of 6 feet or smaller.

8. Slots; One (1) through eight (8) with ½, ¾ & 1 inch slot width as scheduled on drawings

9. Frame/Border; See Air Distribution Device schedule for frame and border types.

10. Accessories;

    a. Alignment strips and pins for continuous diffusers with multiple diffusers sections.

    b. Blank-off strips where called for on drawings. Cold rolled steel with black finish

    c. For straight diffusers, provide extruded aluminum end borders to match at each end.

    d. For diffusers that change direction, provide mitered joints at directional change.

    e. Plaster frame; See architectural drawing for diffusers where construction requires this type frame.

11. Where shown on drawing, diffuser shall be curved to radius called for on drawings. Minimum curvature radius 6 feet.

C. Ceiling/Sidewall-Integral Continuous Diffuser <TITUS MODEL FL>

1. Manufacturers: Subject to compliance with requirements, provide produces by one of the following:

   a. Anemostat Produces; a Mestek company

   b. Carnes

   c. Krueger

   d. Metalaire, Inc.

   e. Nailor Industries Inc.

   f. Price Industries

   g. Titus

   h. Tuttle & Bailey

2. Material; Face and frame/border minimum 0.062 inch extruded aluminum

3. Pattern Controller;

   a. Type 1; Aerodynamically designed to discharged air flow flat against the ceiling plane and designed to maintain air flow at the ceiling plane in a variable air volume application without dumping. Design shall also allow the air flow discharged to be adjusted in either direction.

   b. Type 2; Aerodynamically designed to "jet" the air vertically in a ceiling application and also has the ability to adjust the air flow vector either left or right. For sidewall applications, aerodynamically designed "jet" the air horizontally and also has the ability to adjust the air flow vector either up or down.

   c. Material; Extruded aluminum.

   d. Length; Maximum 24 inches

4. Frame/Border; See Air Distribution Device schedule for frame/border types

5. Finish; Baked acrylic paint, white as scheduled on the drawings or other special finish as scheduled on drawings.

   a. Pattern controller shall be baked acrylic paint, black

6. Slots; One (1) or two (2) as scheduled on drawings

7. Slot Width; 1, 1 ½, 2, 2 1/2 or 3 inch as scheduled on drawings.

8. Accessories;

a. Spline support clips for continuous diffusers with multiple diffusers sections.

b. Blank-off strips where called for on drawings. Cold rolled steel with black finish

c. For straight diffusers, provide extruded aluminum end borders to match at each end.

d. For diffusers that change direction, provide mitered joints at directional change.

e. Mitered cross where called for on drawings

f. Plaster frame; See architectural drawing for diffusers where construction requires this type frame.

g. Where this diffuser type is used for return air, provide a perforated (minimum 51% free area) galvanized sheet metal return hood/ light shield with a baked acrylic paint, black finish.

9. Where shown on drawing, diffuser shall be curved to radius called for on drawings. Minimum curvature radius 6 feet.

2.4 REGISTERS AND GRILLES

A. Adjustable Bar Register (supply, return or exhaust) <TITUS MODEL 300/350 SERIES>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anemostat Products; a Mestek company.

b. Carnes.

c. Krueger.

d. METALAIRE, Inc.

e. Nailor Industries Inc.

f. Price Industries.

g. Titus.

h. Tuttle & Bailey.

2. Construction

a. Steel with 1 ¼ inch border on all sides, full penetration welded corners, steel double deflection blades spaced ¾ inches on center with steel friction pivots at either end of blade to permit individual adjustment of each deflection blade without loosening or rattling. Plastic pivots not acceptable.

b. Aluminum with 1 ¼ inch border on all sides, air distribution devices 24 x 24 inches or smaller shall have rolled borders with a minimum thickness of 0.032 inches; air distribution devices larger than 24 x 24 shall have continuous aluminum extrusions with a minimum thickness of 0.040 through 0.050 inches and shall be interlocked at the four corners and mechanically staked, double deflection blades spaced ¾ inches on center with friction pivots at either end of blade to permit individual adjustment of each deflection blade without loosening or rattling. Plastic pivots not acceptable.

c. Stainless steel (Type 304) with 1 3/8 inch border on all sides, full penetration welded corners, double deflection blades spaced ¾ inches on center with friction pivots at either end of blade to permit individual adjustment of each deflection blade without loosening or rattling. Plastic pivots not acceptable.

3. Finish: Baked acrylic paint, white as scheduled on the drawings or other special finish as scheduled on drawings.

4. Face Blade Arrangement: Horizontal Vertical spaced 3/4 inch (19 mm).

5. Rear-Blade Arrangement: Horizontal Vertical spaced 3/4 inch (19 mm).

6. Mounting: Countersunk screw.

7. Damper Type: Adjustable opposed blade. Damper construction material to match air distribution device construction.

B. Adjustable Bar Grille (Supply):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anemostat Products; a Mestek company.

b. Carnes.

c. Krueger.

d. METALAIRE, Inc.

e. Nailor Industries Inc.

f. Price Industries.

g. Titus.

h. Tuttle & Bailey.

2. Construction

a. Steel with 1 ¼ inch border on all sides, full penetration welded corners, steel single or double deflection blades spaced ¾ inches on center with steel friction pivots at either end of blade to permit individual adjustment of each deflection blade without loosening or rattling. Plastic pivots not acceptable.

b. Aluminum with 1 ¼ inch border on all sides, air distribution devices 24 x 24 inches or smaller shall have rolled borders with a minimum thickness of 0.032 inches; air distribution devices larger than 24 x 24 shall have continuous aluminum extrusions with a minimum thickness of 0.040 through 0.050 inches and shall be interlocked at the four corners and mechanically staked, single or double deflection blades spaced ¾ inches on center with friction pivots at either end of blade to permit individual adjustment of each deflection blade without loosening or rattling. Plastic pivots not acceptable.

c. Stainless steel (Type 304) with 1 3/8 inch border on all sides, full penetration welded corners, single or double deflection blades spaced ¾ inches on center with friction pivots at either end of blade to permit individual adjustment of each deflection blade without loosening or rattling. Plastic pivots not acceptable.

3. Finish: Baked acrylic paint, white as scheduled on the drawings or other special finish as scheduled on drawings.

4. Face Blade Arrangement: Horizontal Vertical spaced 3/4 inch (19 mm).

5. Rear-Blade Arrangement: Horizontal Vertical spaced 3/4 inch (19 mm).

6. Mounting: Countersunk screw.

C. Fixed Bar Register (Return)

1. Manufacturers: Subject to compliance with requirements, provide produces by one of the following:

a. Anemostat Produces; a Mestek company

b. Carnes

c. Krueger

d. Metalaire, Inc.

e. Nailor Industries Inc.

f. Price Industries

g. Titus

h. Tuttle & Bailey

2. Construction

a. Steel with 1 ¼ inch border on all sides, full penetration welded corners, fixed steel single deflection blades spaced ¾ inches on center. Blades shall be held in place by mullions behind grille and fixed to grille by welding

b. Aluminum with 1 ¼ inch border on all sides, air distribution devices 24 x 24 inches or smaller shall have rolled borders with a minimum thickness of 0.032 inches; air distribution devices larger than 24 x 24 shall have continuous aluminum extrusions with a minimum thickness of 0.040 through 0.050 inches and shall be interlocked at the four corners and mechanically staked, fixed single deflection blades spaced ¾ inches on center. Blades shall be held in place by mullions behind grille and fixed to grille by welding

c. Stainless steel (Type 304) with 1 3/8 inch border on all sides, full penetration welded corners, fixed single deflection blades spaced ¾ inches on center. Blades shall be held in place by mullions behind grille and fixed to grille by welding

3. Blade Deflection Angle: 0°, 35°, 45° as scheduled on drawings

4. Finish: Baked acrylic paint, white as scheduled on the drawings or other special finish as scheduled on drawings.

5. Face Blade Arrangement: Horizontal Vertical

6. Mounting; Countersunk screws

7. Damper Type: Adjustable opposed blade. Damper construction material to match air distribution device construction.

D. Fixed Bar Grilles (Return)

1. Manufacturers: Subject to compliance with requirements, provide produces by one of the following:

a. Anemostat Produces; a Mestek company

b. Carnes

c. Krueger

d. Metalaire, Inc.

e. Nailor Industries Inc.

f. Price Industries

g. Titus

h. Tuttle & Bailey

2. Construction

a. Steel with 1 ¼ inch border on all sides, full penetration welded corners, fixed steel single deflection blades spaced ¾ inches on center. Blades shall be held in place by mullions behind grille and fixed to grille by welding

b. Aluminum with 1 ¼ inch border on all sides, air distribution devices 24 x 24 inches or smaller shall have rolled borders with a minimum thickness of 0.032 inches; air distribution devices larger than 24 x 24 shall have continuous aluminum extrusions with a minimum thickness of 0.040 through 0.050 inches and shall be interlocked at the four corners and mechanically staked, fixed single deflection blades spaced ¾ inches on center. Blades shall be held in place by mullions behind grille and fixed to grille by welding

c. Stainless steel (Type 304) with 1 3/8 inch border on all sides, full penetration welded corners, fixed single deflection blades spaced ¾ inches on center. Blades shall be held in place by mullions behind grille and fixed to grille by welding

3. Blade Deflection Angle: 0° 35° 45° as scheduled on drawings

4. Finish: Baked acrylic paint, white as scheduled on the drawings or other special finish as scheduled on drawings.

5. Face Blade Arrangement: Horizontal Vertical

6. Mounting; Countersunk screws

2.5 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Cleanliness of sheet metal.

3.3 INSTALLATION

A. All air distribution equipment shall be installed in accordance with the latest industry standards, per the manufacturer's recommendations and as indicated on the Drawings.

B. General: Install air devices in accordance with manufacturer’s written instructions and in accordance with recognized industry practices to ensure that products serve intended function.

C. Coordinate with other work, including ductwork and duct accessories, as necessary to interface installation of air devices with other work.

D. Ceiling Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location. Changes in duct size and/or location shall be made where necessary to conform to site conditions without additional cost to the Owner.

E. All ductwork and distribution devices indicated on drawings is schematic. Therefore, changes in duct size and/or location shall be made where necessary to conform to space conditions, without additional cost to the Owner.

F. Install diffusers, register, and grilles with airtight connection to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

G. All ductwork; register boxes, air chambers, dampers, and all auxiliary work of any kind, necessary to make the various air conditioning, ventilating and heating systems of the building complete and ready for operation, shall be furnished and installed.

H. The specifications refer to SMACNA standards, which shall be considered minimal. If local codes require other standards than described in SMACNA, local codes shall govern.

I. Dimensions given on drawings of all acoustically lined ducts shall be the clear inside dimension. See Division 23; Section titled “METAL DUCTS” for acoustical lining requirements

J. Furnish and install manual dampers, registers, grilles, register boxes, access doors, sound traps, etc., as described herein and elsewhere in the specifications and as required for a complete system, ready for operation.

K. Exact dimensions of register boxes must await approval of grilles, and exact locations shall be submitted for approval, otherwise any changes directed after installation shall be made without additional cost. All register boxes and other opening of the ductwork must be kept tightly closed during construction to keep out rubbish.

L. This contractor shall be fully responsible for coordinating the electrical power feed arrangements (voltage/phase/amperage) for all devices requiring same, as indicated on the electrical contract documents. In the event that the devices delivered to the site do not comply with the electrical feed arrangements, he shall be fully responsible for all costs incurred to remediate the situation.

3.4 FACTORY TESTING

A. All air distribution equipment shall be tested in accordance with the latest applicable industry standards and as specified herein.

3.5 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 37 13

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SECTION 23 37 23 - HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Goosenecks.

1.3 PERFORMANCE REQUIREMENTS

A. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1.

1.4 COORDINATION

A. Coordinate sizes and locations of roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T5 or T-52.

B. Aluminum Sheet: ASTM B 209 (ASTM B 209M), Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.

C. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 (Z275) zinc coating, mill phosphatized.

D. Stainless-Steel Sheet: ASTM A 666, Type 304, with No. 4 finish.

E. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.

1. Use types and sizes to suit unit installation conditions.

2. Use hex-head or Phillips pan-head screws for exposed fasteners unless otherwise indicated.

F. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.

G. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.2 GOOSENECKS

A. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 6-5; with a minimum of 0.052-inch- (1.3-mm-) thick, galvanized-steel sheet.

B. Roof Curbs

1. Mounted directly on roof

2. Material: Galvanized sheet metal construction with mitered and welded corners and seams.

3. Provide either straight sides and 5 inch flashing flange. 45˚cant and 5 inch flashing flange or raised 45˚ cant and 5 inch flashing flange. Coordinate type with roofing system.

4. Provide wood nailer if required by type of roofing system

5. Insulated roof curb with 1 ½ inches of ridge insulation

6. Coating: Manufacturer’s standard coating

7. For roof curbs mounted directly on a sloped roof, construct roof curb to match roof slope

8. Minimum curb height 12 inches.

C. Galvanized-Steel Sheet Finish:

1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.

2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.

3. Factory Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat and an overall minimum dry film thickness of 2 mils (0.05 mm).

4. For shop fabricated Goosenecks, paint inside and outside surface with two coats of Bituminous Paint as specified in sub-paragraph 2.1.G titled Materials.

D. Capacities and Characteristics:

1. Capacity: See drawings.

2. Width and Depth: See drawing.

3. Minimum of 150°F Deg from vertical.

4. Terminate gooseneck with the lowest portion of outlet a minimum of 30 inches above roof.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install goosenecks on curb base.

B. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

C. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Section 07 92 00 "Joint Sealants" for sealants applied during installation.

D. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

E. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in Division 23, Section titled, "Metal Ducts". Drawings indicate general arrangement of ducts and duct accessories.

END OF SECTION 23 37 23

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SECTION 23 41 00 - PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Pleated panel filters. (Type 1)

2. Rigid cell box filters. (Type 2)

3. Front- and rear-access filter frames.

4. Side-service housings.

5. Filter gages.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

2. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

3. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.

1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.

2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

3. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide two complete (pre-filters and final filters) sets of filters for each air handling unit and air conditioning unit. One set of filters to be installed by the HVAC Contractor immediately prior to the air balancing and testing required in Division 23; Section titled "Testing and Balancing". The other set of filters shall be delivered to the Owner's stock at the time of initial occupancy of project.

2. Provide one container(s) of red oil for inclined manometer filter gage.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."

2. Comply with ASHRAE 52.1 for arrestance and ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

C. Fire Performance Characteristics: Provide filters identical with those tested for the fire performance characteristics indicated. Identify with appropriate markings of applicable testing and inspecting agency.

D. Electrical Component Standard: Provide components that comply with NFPA 70 "National Electrical Code."

E. NEMA Compliance: Provide electrical components required as part of filter assembly that are listed and labeled by UL and comply with applicable NEMA standards.

F. Listing and Labeling: Provide electrical components that are listed and labeled.

1. The Terms "Listed and Labeled": As defined in the "National Electrical Code," Article 100.

2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

G. NFPA Compliance: Comply with applicable portions of NFPA 90A and 90B pertaining to installing air filters.

H. ASHRAE Compliance: Comply with provisions of ASHRAE Standard 52 for method of testing and rating air filter units.

I. AHRI Compliance: Comply with provisions of AHRI Standard 850 pertaining to testing and performance of air filter units.

J. UL Rating: Air filters shall have either a Class 1 or Class 2 rating in accordance with UL 900, standard for test performance of air filter units.

1.7 COORDINATION

A. Coordinate sizes and locations of filters and filter boxes.

PART 2 - PRODUCTS

2.1 GENERAL

A. Air Handling Unit Filter types and sizes shall be as scheduled on the drawings.

B. Coordinate filter frames (single header, double header, box, etc) to ensure compatibility filter section provided by the Air Handling Unit Manufacturer.

C. Size filter face area for the minimum number of filters. Blank-off plates with-in filter section are not permitted.

D. Filter media shall be installed in heavy gauge steel painted with corrosion resistance paint, galvanized steel or aluminum holding frames. Frames shall be complete with gaskets and spring fasteners

E. Filter media shall be fully gasketed to prevent air bypass around the filter sections or between filter modules.

F. Filters located on the suction side of the fan shall be installed on the downstream side of filter so the airflow pressure increases gasket seal. Filters located on the discharge side of the fan shall be installed on the upstream side of filter so that airflow pressure increases gasket seal.

G. Air Handling Unit Manufacturer shall provide side access slide-in type frame with hinged access doors.

H. All filter products shall be National Air Filtration Association certified for performance.

I. Provide a dial type filter gage on each filter bank.

J. At the option of the HVAC Contractor, filter housing maybe purchased directly from the filter manufacturer in lieu of the Air Handling unit manufacturer. If the filter housing cross section does not match the cross section of the air handling unit, the HVAC Contractor shall provide inlet and/or outlet insulated transition section to match cross section of air handling. HVAC Contractor shall verify that the additional length of the air handling unit required for the transition physical fits within the space allocated.

2.2 PLEATED PANEL FILTERS (TYPE 1)

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AAF International.

b. Airguard.

c. Camfil Farr.

d. Columbus Industries, Inc.

e. CRS Industries, Inc.; CosaTron Division.

f. D-Mark.

g. Filtration Group.

h. Flanders-Precisionaire.

i. Koch Filter Corporation.

j. Purafil, Inc.

k. Research Products Corp.

l. Tri-Dim Filter Corporation.

B. Filter Unit Class: UL 900, Class 2.

C. Media: Cotton and synthetic fibers coated with nonflammable adhesive.

1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

3. Media shall be coated with an antimicrobial agent.

4. Separators shall be bonded to the media to maintain pleat configuration.

5. Welded wire grid shall be on downstream side to maintain pleat.

6. Media shall be bonded to frame to prevent air bypass.

7. Support members on upstream and downstream sides to maintain pleat spacing.

8. Expanded metal pleat support.

D. Filter-Media Frame: Moisture resistance cardboard double frame seal or bonded to media.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

F. Capacities and Characteristics:

1. Face Dimensions: Combination of 12 x 24 inches, 24 x 12 inches and 24 x 24 inches.

2. Thickness or Depth: 2 inches (50 mm).

3. Maximum Face Velocity: 250 FPM (m/s).

4. Efficiency: 25 – 30 percent when tested in accordance with ASHRAE 52.1.

5. Arrestance: 95 percent when tested according to ASHRAE 52.1.

6. Initial Resistance: 0..20 inches wg.

7. Final Resistance: 0.50 inches wg.

8. MERV Rating: 8 when tested according to ASHRAE 52.2.

2.3 RIGID CELL BOX FILTERS (TYPE 2)

A. Description: Factory-fabricated, adhesive-coated disposable, packaged air filters with media perpendicular to airflow, and with holding frames.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AAF International.

b. Airguard.

c. Camfil Farr.

d. Columbus Industries, Inc.

e. CRS Industries, Inc.; CosaTron Division.

f. D-Mark.

g. Filtration Group.

h. Flanders-Precisionaire.

i. Koch Filter Corporation.

j. Purafil, Inc.

k. Research Products Corp.

l. Tri-Dim Filter Corporation.

B. Filter Unit Class: UL 900, Class 2.

C. Media: Micro-fine synthetic media laminated to a non-woven backing, bonded to an expanded metal wire grid and pleated to form the filter pack. Grid to maintain taper pleat form under rated airflow conditions.

1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

3. Media shall be coated with an antimicrobial agent.

D. Filter-Media Frames: Minimum 24 ga. corrosion-resistant steel casing with metal or separators on the upstream and downstream sides to maintain pleat configuration. Filter media sealed to frame to prevent air by-pass. Filter designed shall be box type or header type as required by filter housing.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

F. Capacities and Characteristics: (Type 2)

1. Face Dimensions: Combination of 12 x 24 inches, 24 x 12 inches and 24 x 24 inches.

2. Depth: 4 inches

3. Efficiency 90 – 95 Percent

4. Maximum Face Velocity: 250 FPM

5. Arrestance: 99 percent when tested according to ASHRAE 52.1

6. Initial Resistance: 0.12 inches wg.

7. Final Resistance: 0.40 inches wg.

8. Merv Rating: 14

2.4 FRONT AND REAR-ACCESS FILTER FRAMES

A. Framing System: Galvanized-steel framing members with access for either upstream (front) or downstream (rear) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AAF International.

b. Airguard.

c. Camfil Farr.

d. Columbus Industries, Inc.

e. CRS Industries, Inc.; CosaTron Division.

f. D-Mark.

g. Filtration Group.

h. Flanders-Precisionaire.

i. Koch Filter Corporation.

j. Purafil, Inc.

k. Research Products Corp.

B. Framing System

1. Coordinate filter frame configuration with air handling unit manufacturer prior to fabrication of filter frame.

2. Galvanized Steel orAluminum framing members of adequate gauge to support filters designed for front and rear access for filter servicing.

3. Filter frame shall be designed to accommodate a pre-filter and final filter.

4. Incorporate, a separate track with spring clips removable from front for pre-filter.

5. Framing members for filter subassemblies shall be factory sized, cut, pre-punched and marked for assembly into modules and configured for stacking of filters.

6. Subassembly shall be bolted in field based on the configuration above.

7. Provide vertical support to prevent deflection of horizontal members of the framing system. Support system shall be designed so as not to interfere with airflow or access to filters for removal.

8. Permanently gasket framing members to prevent unfiltered air from by-passing filter frame.

9. Provide a factory installed, positive-sealing system for each row of filters to ensure air seal between gasketed filter elements.

10. Provide all necessary hardware, fasteners and fittings to mount filters in filter frame.

11. Provide all hardware necessary for field assembly of filter frame 12. Provide a galvanized steel or 304 stainless steel base to support filter frame.

C. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1

2.5 SIDE-SERVICE HOUSINGS

A. Description: Factory-assembled modular design side-service 2 stage (pre-filter and final filter) filter housing designed to accommodate 2 inch prefilters and 4 inch supported rigid filters. Units shall be flanged suitable of insulation in a duct or attached to an air handling unit casing.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AAF International.

b. Airguard.

c. Camfil Farr.

d. Columbus Industries, Inc.

e. CRS Industries, Inc.; CosaTron Division.

f. D-Mark.

g. Filtration Group.

h. Flanders-Precisionaire.

i. Koch Filter Corporation.

j. Purafil, Inc.

k. Research Products Corp.

B. Construction of filter shall be suitable for a static pressure range for -10 in. w.g. (positive/negative). The leakage rate shall be less than 1.0% of air flow at 10 in. w.g. internal static pressure.

C. Housings are constructed of 16 ga. aluminized steel with upstream and downstream outwardly-turned flanges. Units wider than 4 ft. include intermediate support channels.

D. Filter tracks shall be extruded aluminum. The primary track accepts nominal 4 in. to 36 ins. thick filter headers and the pre-filter track accepts 2 in. or 4 in. thick panel filters. Both tracks are gasketed with replaceable polypropylene pile air seals.

E. Housings are equipped with two access doors that are sealed with neoprene gasketing on the perimeter. Gasketing shall seal the filter edge to the door.

F. Doors are equipped with 1-1/2 in. positive-sealing knobs made of UV-resistant plastic with corrosion-resistant brass inserts.

G. Sealing: Incorporate positive-sealing gasket material on channels to seal cartridge frames and to prevent bypass of unfiltered air.

H. Filter Housing design shall provide for interchanging of header type filters and different ASHRAE efficiencies as required.

I. Flanges shall be provided to accommodate in-line installation with air handling units and ductwork configuration.

J. Where more than one filter housing is required to meet the air capacity requirements, the housings shall be provided with comer posts pre-punched and gasketed for butting units together, and/or standing flanges for stacking the units on top of one another.

K. Where filter housing are installed outdoors, weatherproof units for outside installations consist of a pitched roof, rain guards over the doors and caulking of all seams.

L. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1

2.6 FILTER GAGES

A. Diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Airguard.

b. Dwyer Instruments, Inc.

2. Diameter: 4-1/2 inches (115 mm).

3. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg (125 Pa) or Less: 0- to 0.5-inch wg (0 to 125 Pa).

4. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg (125 to 250 Pa) or Less: 0- to 1.0-inch wg (0 to 250 Pa).

B. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale and logarithmic-curve tube gage with integral leveling gage, graduated to read from 0- to 3.0-inch wg (0 to 750 Pa), and accurate within 3 percent of the full scale range.

C. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

D. Provide filter gage static pressure tips upstream and downstream of each filter type in the filter bank to indicate filter pressure of each filter type.

E. Provide filter gage for each filter type in the filter bank.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install filter frames and filter housing level and plumb following manufacturer's written instructions, rough-in drawings and reference standards.

B. Install air filters and holding devices of types indicated on drawings following filter manufacturer's written instructions and with recognized industry practices to ensure that filters comply and perform with requirements and serve intended purpose.

C. Locate each filter accurately in position indicated in relation to other work

D. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

E. Install filters in position to prevent passage of unfiltered air.

F. Install filter gage for each filter bank.

G. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

H. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

I. Coordinate filter installations with duct and air-handling-unit installations.

J. For each air handling unit and air conditioning unit that is to be used during the construction phase, provide two complete sets of 2 inch thick minimum MERV 7 replaceable media (Type 1) filters. One set shall be installed when the systems are initially started for use during the construction phase. The second set shall be installed at the direction of the Owner.

K. Fan fan coil units that are operated during the construction period, HVAC Contractor shall install a temporary air filter with frames on each return air opening. Temporary air filters shall be 1 inch thick glass fiber. Temporary air filters shall be removed at the start of air balancing. After air balancing is completed, temporary filters shall be replaced. Temporary air filters shall be removed at the time of initial occupancy of the project after the HVAC Contractor notifies the Owner. If the temporary air filter are not maintained during the construction phase up to the time of initial occupancy and the fan powered variable air volume terminal boxes and fan coil units internal surface become contaminated with dust or other foreign material, the HVAC Contractor shall clean the terminal boxes and fan coil units at no additional cost to the Owner.

3.2 FIELD QUALITY CONTROL

A. HVAC Contractor Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Test for leakage of unfiltered air while system is operating.

2. Leak-test housing by pressurizing to a minimum 3 inches wg. (750 Pa) or designed operating pressure. Soap-bubble test housing, joints, door seals and filter sealing edges.

C. Air filter will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.3 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 23 41 00

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SECTION 23 72 10 – PACKAGED ENERGY RECOVERY UNIT (100% OUTSIDE AIR)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Packaged Energy Recovery Units (100% Outside Air).

1.3 PERFORMANCE REQUIREMENTS

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. LEED Submittals:

1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
2. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings: For Energy Recovery Units. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.
3. Performance requirements for overall system and each system component.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
5. Calculate requirements for selecting vibration isolators and where required for designing vibration isolation bases.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Structural members to which equipment will be attached.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Packaged Energy Recovery Unit to include in maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set of each type of filter specified.
2. Fan Belts: One set of belts for each belt-driven fan in Energy Recovery Units.
3. Wheel Belts: One set of belts for each heat wheel.

1.8 REFERENCE STANDARDS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. AHRI Compliance:

1. Capacity ratings for Packaged Energy Recovery Unit shall comply with AHRI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."
2. Capacity ratings for air coils shall comply with AHRI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils."

C. ASHRAE Compliance:

1. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."

D. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.

E. UL Compliance:

1. Packaged energy recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators."
2. Electric coils shall comply with requirements in UL 1995, "Heating and Cooling Equipment."

AFBMA 9:	Load Ratings and Fatigue Life for Ball Bearings
AMCA 210:	Laboratory Methods of Testing Fans for Rating Purposes
AMCA 300:	Test Code for Sound Rating Air Moving Devices
AMCA 500:	Test Methods for Louvers, Dampers and Shutters
AHRI 410:	Forced Circulation, Air Cooling and Air Heating Coils
NEMA MG-1:	National Electrical Manufacturers Association Motor Standard
NFPA 90A:	Standard for the Installation of Air Conditioning and Ventilating Systems
SMACNA:	Sheet Metal and Air Conditioning Contractors National Association
UL 900:	Test Performance for Air Filter Units

1.9 QUALITY ASSURANCE

A. Unit manufacturer shall have a minimum of 10 years' experience in the energy recovery market.

B. The system shall deliver the specified air volume at the static pressure scheduled.

C. The unit shall be constructed to provide smooth interior surfaces and to limit the casing leakage at less than 1% of the specified air volume at operating static.

D. Unit shall be constructed in accordance with CSA C22.2 and UL 1812 and shall carry the ETL label of approval.

E. Unit shall be constructed in accordance with industrial design practices.

F. Insulation shall comply with NFPA 90A requirements for flame spread and smoke generation.

G. Airflow data shall comply with AMCA 210 method of testing.

H. Cabinet and exterior components shall be tested and certified weatherproof.

I. All units shall be 100% factory tested.

J. All effectiveness data of heat and energy recovery components shall be certified by the AHRI 1060 certification program directory.

1.10 COORDINATION

A. Coordinate layout and installation of Packaged Energy Recovery Unit and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.11 WARRANTY

A. Special Warranty: manufacturer's standard form in which manufacturer agrees to repair or replace components packaged heat recovery units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Packaged Energy Recovery Units: two years from owner's acceptance.

PART 2 - PRODUCTS

2.1 PACKAGED ENERGY RECOVERY UNIT - GENERAL

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
1. Daikin
2. Haakon
3. Aaon
4. Venmar CES Inc.
5. Semco Incorporated

B. Unit components

1. Unit Double-Walled Casing

2. Supply Fan
3. Exhaust Fan
4. Direct Expansion Cooling Coil
5. Heat Recovery Wheel Total (sensible plus latent) Heat
6. Refrigeration System
7. Filters
8. Heating Coil (Located downstream of cooling coil)
9. Standalone Factory packaged Control System to maintain unit leaving air temperature.
10. Interface with Building Management System (BMS)

C. Unit shall be factory assembled and tested including leak testing of the coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the controls compartment's literature pocket.

D. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.

E. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.

F. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's access door.

G. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's access door.

2.2 CASING

A. The Energy Recovery Unit shall be suitable for installation either outdoor or indoor as indicated on the drawings. If unit is for an outdoor installation, unit shall be specifically designed for outdoor use. Indoor units weatherized for outdoor use are not acceptable.

B. All panel joints must be caulked with a weatherproof silicone. After application, the silicone must react with atmospheric moisture to produce a formed-in-pace silicone rubber glazing and curtain wall seal.

C. Unit shall be designed to reduce air leakage and infiltration through the cabinet.

1. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360.
2. Panel deflection shall not exceed L/240 ratio at of design static pressure of maximum 8 inches of positive or negative.
3. Deflection shall be measured at the midpoint of the panel height and width.

4. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Refrigerant piping, water piping, electrical conduit, etc. penetrating cabinet panels shall be sealed to reduce air leakage.
5. The unit base frame shall be constructed from a bolted or welded, structural formed G90 galvanized steel with internal structural cross members properly sized to allow rigging and handling of the unit.

    a. The deflection of the base frame shall be less than 1/360 the length of the unit when rigging.
    b. All major components shall be supported by the base without sagging or pulsating.
    c. Lifting lugs shall be provided and strategically located per section to allow equilibrium during lifting.
    d. For outdoor units scheduled to be set on roof curbs, the unit base frame shall be self flashing when set on roof curb.

6. Unit floor shall be double wall construction and be insulated with 4" fiberglass insulation (R16).

    a. Floor shall be constructed of 16 gauge G90 galvanized steel welded.
    b. Bottom face of insulation shall be protected with a 22 gauge G90 galvanized steel.
    c. Floor shall be designed to accommodate roof curb, raised structural frame or concrete pad installation.
    d. Single wall floor construction and non-insulated floor shall not be acceptable.
    e. Floor openings (supply, exhaust, return) shall be provided with upturn flanges at least ½ in height around opening.

7. Wall and roof construction shall be double-walled insulated construction.

    a. Solid G90 18 gauge galvanized steel.
    b. Interior skin solid G90 22 gauge galvanized steel
    c. Double-walled construction shall be 2 inch thick and insulated with 3.0 pounds be cubic foot with a minimum assembled insulation "R" value of 13.0 Btu/Hr/Sq. Ft./°F.
    d. Unit construction (manufacturer's standard frame) shall be adequate to meet or exceed the criteria outlined above.
    e. Outdoor units shall have a pitched roof (3% minimum) to dissipate water accumulation. Rain gutters shall be provided above access doors. All roof joint seams shall be "T" shape construction, minimum height of 1.5", sealed and encapsulated by a metal strip.

f. Outdoor air intake and exhaust air opening shall be provided with hoods constructed of G90 galvanized sheet with openings protected with a bird screen. Outdoor air intake shall be adequately sized to eliminate entrainment of water in the air stream.
g. Internal partitions shall be double-walled insulation construction as outlined above for exterior skin.

8. Access doors
   a. Full size access door(s) shall be provided to allow for periodic maintenance and inspections for all serviceable components. For heat recovery section, provide access doors upstream and downstream to facilitate coil cleaning.
   b. Doors shall be double wall construction made of 18 gauge galvanized steel on both outer and inner liner for maximum rigidity.
   c. Door insulation shall be the same as the unit panels.
   d. Provide doors with heavy duty corrosion resistant aluminum hinges that allow the door to open at 180°.
   e. Cam type handles operable from both sides of the unit access door(s) and neoprene resilient bubble gaskets for an enclosure that is sealed tight shall be provided.
   f. Door openings shall be flush with all surrounding panels.
   g. Plastic latches and continuous hinges are not acceptable.
   h. Hold open device on all access doors shall be provided.

2.3 CONDENSATE DRAIN PAN

A. Provide a condensate drain pan under cooling coils and other unit components where moisture may occur.

B. Condensate drain pan shall comply with ASHRAE 62.1.

C. Double-wall insulated drain pan shall be constructed of 16 gauge type 304 stainless steel (wet side), insulated with a minimum 1 inch high density insulation adhered to the stainless steel and covered with 20 gauge galvanized metal.

D. Drain pan shall be sloped to a 1 ½ inch stainless steel pipe drain connection at the low point of drain pan. Slope of main drain pan within unit to allow pan to drain completely dry on unit shut down.

E. For units with multiple (stacked) coils, provide stainless steel trough for each coil above bottom coil and individually piping each trough to condensate drain pan.

F. Drain pan shall extend a minimum 2 inch upstream of entering side of coil and extend downstream of leaving side of coil a distance to comply with ASHRAE 62.1 or a minimum of 12 inches.

2.4 FANS

A. Supply and exhaust fans shall be either double width double inlet (DWDI) or "un-housed" plenum centrifugal fans.

B. Fan wheel for DWDI centrifugal fans shall be non-overloading; shall be either airfoil or back-incline type. Fan wheel for "un-housed plenum centrifugal fans shall be airfoil type.

C. For fan requirements, see Division 23; Section titled "Centrifugal HVAC Fans."

D. For Motor Requirements, see Division 23; Section titled "Centrifugal HVAC Fans" and Division 23; titled "Common Motor Requirements for HVAC Equipment."

E. For Vibration Isolation and where required seismic restraint devices requirements, see vibration section in Division 23.

2.5 DIRECT EXPANSION COOLING COIL

A. Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized (304 stainless) steel end casings. Fin design shall be sine wave rippled.

B. Coils shall have interlaced circuitry and shall be standard capacity.

C. Coils shall be helium leak tested.

D. Coils shall be provided with a factory installed thermostatic expansion valves.

2.6 ELECTRIC HEATING COILS

A. The electric heater casing is constructed of galvanized steel. Heater terminal box access door shall be mounted on the unit. Element construction as follows:

1. The electric heater casing is constructed of galvanized steel. Heater terminal box access door shall be mounted on the unit. Element construction as follows:

a. Open-wire type, 80% nickel, 20% chromium resistance coils, insulated by Steatite bushings and supported a galvanized steel frame. Bushings shall be recessed into embossed openings and stacked into supporting brackets, spaced no more than 4-in. centers. Maximum element heating density shall be 55 watts/sq. inch. Where electric heater manufacturer requires, element heating density shall be less than 55 watts/sq. inch as recommended.
b. Sheathed type, 80% nickel, 20% chromium resistance coils, suspended in a magnesium oxide insulator fill within a tubular steel sheath/brazed fin assembly. Silicone rubber end seals shall prevent contamination of the interior, and the exterior shall be protected from corrosion by a high temperature aluminum coating.
c. Provide protective screen on both sides of coil.
d. Pressure plate at inlet of heater to evenly distribute air across coil.

2. Each coil shall be constructed and installed in accordance with the requirements of local Authorities having jurisdiction and shall be UL approved and listed for zero clearance.

3. Each coil shall meet all of the requirements of the latest edition of the National Electric Code.

4. Each Coil shall be given a 2,000 Volt dielectric test.

5. Each electric heating coil shall be provided with an insulated terminal box and cover of suitable size to contain all of the power, controls and appurtenances required for the coil.

6. Terminal bolts, nuts and washers shall be of corrosion resistance material.

7. Each heater shall be provided with, but not limited to, the following.

a. Built-in snap-action door interlock disconnect switch.
b. Automatic and manual thermal cut-outs serviceable through the terminal box.
c. Differential air pressure or airflow switch to de-energize heater if no air flow.
d. Disconnecting, safety, controlling and back-up contractor as required for heating element type and control option. Contractors shall be of mercury type.
e. Branch circuit fusing for each 48 amp circuit per National Electric Code.
f. Separate 120 or 124 volt fused control power transformer with primary and secondary protection.
g. Terminal blocks shall be provided for all field wiring (power and control) and shall be sized for installation of 75°C copper wire, rated in accordance with NEC requirements.

h. Heaters shall be rated for the voltage, phase, and number of heating stages indicated in the schedule. All three-phase heaters shall have equal, balanced, three-phase stages. All internal wiring shall be stranded copper with 105°C insulation and shall be terminated in crimped connectors or box lugs.

8. Heater shall be suitable for control as follows:

a. Three phase heaters with total ampere draw of less than 96 amps shall be provided with SCR (proportional control).
b. Three Phase heaters with total ampere draw greater than 96 amps shall be arranged for a Vernier Proportion Control (SCR and step control).

9. Heaters shall be provided with all appurtenances as required to meet requirements of the National Electric Code or any other Codes having jurisdiction.

10. Electric heaters shall be UL listed for zero clearance and shall meet all applicable National Electric Code requirements.

11. Units with electric heat sections shall be listed under UL 1995 Standard for Safety.

2.7 FILTERS

A. Filters shall be provided in the outside air system and the exhaust air stream up-stream of the recovery equipment.

1. Outside air

a. 2 inch disposable; MERV 8
b. 4 inch ridge; MERV 14

2. Exhaust air

a. 2 inch disposable; MERV 8

B. For filter requirements, see Division 23; Section ‘Particulate Air Filtration.”

C. Provide differential pressure gauges as required.

2.8 DAMPERS

A. Air leakage through a 48” x 48” damper shall not exceed 10.3 cfm/sq/ft/ against 4 in. wg. Differential static pressure at standard air. Standard air leakage date to be certified under AMCA certified rating program.

B. Dampers are designed for operation in temperatures ranging between minus (-)40°C) and 212°F (100°C).

C. Unit shall be equipped with all necessary dampers. Dampers for outside air intake, exhaust air and all other dampers required for the system, including the dampers for defrost (if required).

D. Dampers shall be opposed blade type for modulating applications and parallel blade type for two positions. For other dampers, see manufacturer's recommendations.

E. Outside air dampers shall be motorized. Provide damper actuators with 24 VAC drive voltage or 0-10 VDC modulation available when needed.

F. Exhaust air dampers shall be motorized. Provide damper actuators with 24 VAC drive voltage or 0-10 modulation available when needed.

G. Dampers construction shall be as follows:

1. Damper frame shall be extruded aluminum.
2. Blades shall be extruded aluminum.
3. Dampers shall be opposed blade type or parallel blades where indicated.
4. Damper blade ends shall be sealed with neoprene flexible edge seals complete with bottom and top blade wiper seals.
5. Frames and blades shall be non-insulated.

2.9 HEAT RECOVERY WHEEL

A. Heat wheel shall be designed to transfer total energy (sensible plus latent heat) from the exhaust air stream to the outside air stream.

B. The rotor (wheel) housing shall be a structural framework which limits the deflection of the rotor due to air pressure loss to less than 1/32". The housing is made of galvanized steel to prevent corrosion. The rotor shall be supported by two pillow block bearings which can be maintained or replaced without the removal of the rotor from its casing or the media from its spoke system. Bearing shall be either grease lubricated with grease fitting extended to casing exterior or permanently lubricated type.

C. The rotor shall be provided in segmented fashion to allow for field erection or replacement of one media section at a time. The media shall be rigidly held in place by a structural spoke system made of extruded aluminum.

D. The rotor shall be supplied with labyrinth seals, which at no time shall make contact with any rotating surface of the exchanger rotor face. The multi-pass seals shall utilize four labyrinth stages for optimum performance. Seals shall also be provided on divider partition and purge section.

E. Rotor Media

1. The rotor media shall be made of aluminum and coated to prohibit corrosion.
2. All media surfaces shall be coated with a non-migrating solid adsorbent layer prior to being formed into the honeycomb or corrugated media structure to ensure that all surfaces are coated and that adequate latent capacity is provided.
3. The media shall have a flame spread of less than 25 and a smoke developed of less than 50 when rated in accordance with ASTM E84.
4. The faces of the total energy recovery wheel shall be sealed with an acid resistant coating to limit surface oxidation anti-stick additive to limit the collection of dust or smoke particulate and to aid in the surface cleaning process should cleaning be required.
5. The entire recovery wheel media face shall be treated with an antimicrobial agent. The antimicrobial agent shall carry EPA registration for use in duct systems.
6. The media shall be coated with an inorganic desiccant specifically developed for the selective adsorption of water vapor. The desiccant shall utilize a molecular sieve certified by the manufacturer to have an internal pore diameter distribution which limits adsorption to materials not larger than the critical diameter of a water molecule (2.8 angstroms.)
7. Dry particles up to [600] [800] [1200] microns shall pass freely through the media.
8. The following certifications tested by a qualified independent shall be submitted:

    a. Effectiveness of the anti-stick to limit the collection dust and smoke particulate and to aid in the surface cleaning process.
    b. Effectiveness of the antimicrobial agent.
    c. Desiccant surfaces exhibit bacteria-static properties.
    d. The cross-contamination and performance certification reports documenting that the desiccant material utilized does not transfer pollutants typically encountered in the indoor air environment.
    e. Documentation of the heat wheel's sensible and latent recovery efficiencies when conducted in accordance with ASHRAE 84-78P and the results presented in accordance with AHRI 1060 standards.

F. Purge Sector

1. The unit shall be provided with a factory set, field adjustable purge sector designed to limited cross contamination to less than .04 percent of that of the exhaust air stream concentration when operated under appropriate conditions.

G. Media Cleaning

1. The media shall be cleanable with low-pressure steam (less than 5 PSI), hot water or light detergent, without degrading the latent recovery.

H. Rotor Drive

1. Variable speed control shall be accomplished by the use of a VFD

2. The VFD shall include all digital programming.

3. The drive system shall allow for a turndown ratio of 80:1 (20 rpm to 1/4 rpm).

2.10 REFRIGERANT SYSTEM

A. Unit shall be factory charged with R-410A refrigerant.

B. Refrigerant system shall be complete with compressors, direct expansion (DX) cooling coils, refrigerant piping, expansion valves, and refrigerant appurtenances required for a fully operational system. For applications that utilize an air cooled condenser, refrigerant piping shall be extended to the exterior of the unit and capped for field piping to air cooled condenser.

C. Compressors shall be scroll type with thermal overload protection, independently circuited, and carry a 5 year non-prorated warranty.

D. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam insulated panels to prevent the transmission of noise outside the cabinet.

E. Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area. Manufacturer shall submit certification that the vibration isolation will not transmit sound or noise into the building structure.

F. Each refrigeration circuit shall be equipped with thermostatic expansion valve type refrigerant flow control.

G. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides, and factory installed liquid line filter driers.

H. Unit shall include [1] [2] [4] stages of capacity control.

I. Unit shall include a variable capacity scroll compressor on the all refrigeration circuit(s) which shall be capable of modulation from 10-100% of its capacity.

J. Lead refrigeration circuit(s) shall be provided with hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.

K. Each refrigeration circuit shall be equipped with a liquid line sight glass.

L. Each refrigeration circuit shall be equipped with suction and discharge compressor isolation valves.

M. Each capacity stage shall be equipped with a 5 minute off, delay timer to prevent compressor short cycling.

N. Each capacity stage shall be equipped with an adjustable, 20 second delay timer to prevent multiple capacity stages from starting all at once.

O. Lead (All) (Lag) refrigeration circuit(s) shall be provided with factory installed hot gas bypass to protect against evaporator frosting and to prevent excessive compressor cycling.

P. Lead refrigeration circuit shall be provided with hot gas reheat coil, on/off control valves and a control signal terminal which allow the unit to have a dehumidification mode of operation.

Q. Each refrigeration circuit shall include adjustable compressor lockouts.

R. For applications with an air cooled condenser, the first capacity stage shall be provided with on/off condenser fan cycling and adjustable compressor lockout to allow cooling operation down to 35°F.

S. Each refrigeration circuit shall be provided with an adjustable temperature sensor freeze stat which shuts down the cooling circuits when the evaporator coil tubing falls below the set point.

2.11 ROOF CURBS

A. Roof curb shall be supplied by the unit manufacturer for field assembly.

B. See vibration section in Division 23 for roof curb requirements in addition to the requirements listed below.

C. Curb shall be capable of supporting and constructed of galvanized steel sections, double wall with 2” thick fiberglass insulation. Stiffeners shall be provided for field assembly as required.

D. Curbs shall be fully gasketed between the curb top and unit bottom with the curb providing full perimeter support, cross structure support and air seal for the unit.

E. Curb shall be adjustable up to 3/4 inch per foot to allow for sloped roof applications.

F. Curb shall be a custom per design drawing details.

2.12 LIGHTS AND GFI RECEPTACLE

A. Vapor tight lights (marine) shall be located throughout unit for proper maintenances of all components in the unit.

B. Lights shall be wired to a single switch on the unit exterior mounted in a weatherproof junction box.

C. A GFI receptacle shall be provided mounted in a weatherproof junction box next to the light switch.

2.13 One electrical point of connection for the 480v operation of the unit, with a separate convenience outlet powered through the unit with its own disconnect and fusing. ELECTRICAL

A. All electrical controls shall be ETL listed and the entire unit shall be factory wired in accordance with the National Electric Code Standard.

B. Provide a NEMA type enclosure to house all electrical components for a fully operation unit. Enclosures shall be as follows:
   1. Outdoor Enclosures; NEMA 250; Type 4

C. Units shall be supplied with a non-fused main power disconnect switch. A single point power connection shall be provided for all units.

D. The following is a partial list of high voltage components necessary for an operational unit. Manufacturer shall provide all additional components for a fully operational unit.

   1. Motor starters on all high voltage motors for constant speed applications. See Division 23; Section titled “Enclosed Controllers” for motor starter requirements
   2. Thermal protection on all high voltage motors.
   3. Fuses and fuse holders.
   4. All necessary control transformers.
   5. Supply and exhaust/return fans shall be provided with ECM control. Unit is a constant volume system and variable frequency drives shall be used for balancing only.

E. Unit shall be completed with all necessary relays, time delay, damper actuators with auxiliary switches (as required).

F. Unit shall be start and stopped from a signal from a Building management System (BMS).

G. Terminal board shall be provided for low voltage control wiring. Low voltage is 24V.

H. An integral control panel for factory mounted controls and interface with the Building management shall be provided having a hinged access door and an approved locking device.

I. All control devices, except those not mounted directly to the unit, shall be factory mounted and wired. Control panel shall have a labeled strip to land all wires for field installed control components.

J. All components are fully wired and 100% tested prior to shipping.

K. Marine type lights complete with one switch per access door wired to: junction box, disconnect, or transformer.

L. Fan access doors are equipped with a momentary interrupt switch that shuts off the unit when a protected door is opened. These switches can be removed if belt guards are installed on the fan assembly.

2.14 CONTROLS

A. Unit shall be provided with a factory mounted Direct Digital Control (DDC). Control system shall include the capability of interfacing with the Building Management System (BMS) as outlined below. Refer to drawing M-704 and M-705 for diagram, points, and sequences.

B. Control Sequence:

1. When unit receives signal to start, outside air damper shall open and exhaust air damper shall open. When both dampers fully opened as determined by an end switch, supply and exhaust fan shall start. When unit receives a signal to stop, supply fans and exhaust fans shall stop and after a 30 second delay (adjustable), outside air and exhaust air dampers shall close.

2. Application with direct expansion cooling coil and refrigerant system:

a. When the outside air temperature is above 55°F (adjustable):

(i) A temperature sensor located downstream of the direct expansion cooling coil shall modulate in sequence the heat recovery wheel and refrigeration system to maintain 55°F (adjustable) cooling coil leaving air temperature.

(ii) A temperature sensor located downstream of the hot gas refrigerant heating coil and the electric heating coil control valve shall modulate in sequence to maintain 68°F (adjustable) until leaving air temperature.

(iii) When refrigeration cycle is activated, control valve on condenser water supply shall open and when refrigeration cycle is de-activated, the control valve shall stop.

(iv) When refrigeration cycle is activated, air cooled condenser shall be activated and control sequence to control condensing of refrigerant.

b. When the outside air temperature is below 50°F (adjustable):

(i) Refrigerant cycle shall be de-activated and temperature sensor located downstream of cooling coil shall be reset to 68°F (adjustable) and shall modulate heat recovery wheel to maintain its setting.

(ii) Temperature sensor located downstream of electric coil shall modulate to maintain 68°F (adjustable) unit leaving air temperature.

C. Frost prevention temperature sensor shall be provided to prevent frost from occurring on the heat wheel through the use of the Wheel VFD.

D. Wheel effectiveness control will be provided by the Wheel VFD which will modulate its speed to meet the discharge air temperature (DAT) set point using factory mounted temperature sensors. The energy wheel is the first form of heating or cooling when active. Compressors or heat will only be active when the energy recovery wheel cannot satisfy the discharge air temperature. The heat will turn off when not needed.

E. Smoke detector (provided as part of the work of Division 26) located in the discharge air duct shall stop unit in the event smoke is detected. The smoke detector will be interlocked for a FA shutdown command from the Fire Alarm Control Panel.

F. Unit manufacturer shall include, as part of the unit, hot gas control valve, temperature sensors, damper operators and all appurtenances necessary for a full operational control system.

G. Unit manufacturer shall also include provisions to allow for the items listed in following subparagraph to interface with the Building management System (BMS). The interface shall be set up for 0-10V or 4-20 ma signals.

H. The following shall be controlled or monitored by the Building management System.

1. Unit start/stop
2. Cooling coil discharge air temperature
3. Heating coil discharge air temperature
4. Exhaust air dirty filter alarm
5. Outside air dirty pre-filter alarm
6. Outside air dirty secondary filter
7. Heat wheel-failure to rotate
8. Common unit trouble alarm

2.15 UNIT PIPING

A. Units using a refrigeration system with a remote air cooled condenser refrigerant piping shall be extended to the exterior of the unit and capped by unit manufacturer.

2.16 CAPACITY AND CHARACTERISTICS

A. See drawing for Package Heat Recovery Unit schedule.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for all services (piping, electrical, controls, etc.) to verify actual locations of connections before installation.

D. Examine locations for indoor units on concrete equipment pads, roof preparation for roof curbs and structural frame for outdoor units mounted above roof for size, anchors locations, vibration provisions, etc.

E. Examine roof and or wall openings to verify size and locations of opening.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Outdoor Unit set on roof curb

1. Install curb on roof structure or concrete base, level and secure, according to the NRCA "Roofing and Waterproofing Manual – Volume 4: Construction Details – Low-Slope Roofing," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts."

2. Install unit curbs and coordinate roof penetrations and flashing with roof construction specified in Division 07; Section titled "Thermal and Moisture Protection."

3. See vibration section in Division 23 and provide vibration isolation and where required seismic restraint devices.

4. Secure unit to upper curb rail, and secure unit to upper curb rail and secure curb base to roof structure or concrete base with anchor bolts.

5. Coordinate roof penetrations.

B. Outdoor units set on a structural frame.

1. Structural support frame shall be provided as part of the work of another contractor. HVAC contractor shall furnish setting diagrams, unit support points, unit weight at each supports point, templates, etc. to contractor responsible for structural frame.

2. Install unit of structural frame and shim unit to level unit.

3. See vibration section in Division 23 and provide vibration isolation between unit and structural frame and where required seismic restraint devices.

4. Secure unit to structural frame.

5. Coordinate roof penetrations.

C. Install wind (outdoor units only) restraint as required to meet requirements in vibration section of Division 23 and manufacturer's recommendations.

D. Pipe drains from drain pans to nearest floor drain; use ASTM B 88, Type L, drawn-temper copper water tubing with soldered joints, same size as condensate drain connection.

E. Install new filters at completion of equipment installation just prior to the start of testing, adjusting and balancing.

3.3 CONNECTIONS

A. Install piping adjacent to unit to allow service and maintenance.

B. Connect cooling condensate drain pans with air seal trap at connection to drain pan and install cleanouts at changes in pipe direction.

C. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." For applications with Air Cooled Condenser, coordinate with Air Cooled Condenser manufacturer and size refrigerant piping based on final pipe routing and extend piping between unit and air cooled condenser.

D. Comply with requirements for ductwork specified in Division 23; Section titled "Metal Ducts" and Section titled "Air Duct Accessories."

E. Coordinate final connections of the Building management System to the unit.

F. Coordinate Contractor of Division 26 final electric power to unit.

3.4 FIELD QUALITY REPORTS

A. Perform inspection, test and adjust.

1. HVAC contractor shall engage a factory-authorized service representative assist in testing and adjusting of unit.

B. Tests and Inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Adjust seals and purge.

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

4. Set initial temperature and humidity set points. Set points to be adjustable.

5. Set field-adjustable switches and circuit-breaker trip ranges as required for proper operation of unit.

6. Verify date transmission to Building Management System (BMS).

7. Record temperature as follows:

a. Outside air (upstream of heat recovery equipment)
b. Outside air (downstream of heat recovery equipment)
c. Exhaust air (upstream of heat recovery equipment)

d. Exhaust air (downstream of heat recovery equipment)

C. Packaged energy recovery equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain packaged heat recovery units. Include 8 hours of on-site and 8 hours of classroom training.

END OF SECTION 23 72 10

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SECTION 23 81 29 – VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes complete VRF HVAC system(s) including, but not limited to the following components to make a complete operating system(s) according to requirements indicated:
1. Indoor Units – Ducted (Ceiling-mounted)
2. Indoor Units – Ductless (Wall-mounted, ceiling-mounted cassette, ceiling suspended)
3. Outdoor, air-source, condensing units – 3 phase power (heat pump and/or heat recovery).
4. Heat recovery control units.
5. System controls.
6. System refrigerant and oil.
7. System control cable and raceways.

1.3 DEFINITIONS

A. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.

B. Heat-Pump System Operation: System capable of operation with all zones in either heating or cooling, but not with simultaneous heating and cooling zones that transfer heat between zones.

C. Heat Recovery System Operation: System capable of operation with simultaneous heating and cooling zones that transfer heat between zones.

D. HRCU: Heat Recovery Control Unit. HRCUs are used in heat recovery VRF HVAC systems to reverse the flow of refrigerant between the HRCU and the Fan Coil. "Heat Recovery Control Unit" is the term used by ASHRAE for what different manufacturers term as branch circuit controller, branch selector box, heat recovery unit, changeover box, flow selector unit, mode change unit, and other such terms.

E. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

F. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

G. VRF: Variable refrigerant flow.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for indoor and outdoor units and for HRCUs.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include operating performance at design conditions.
4. Include minimum allowable ambient temperatures for simultaneous heating and cooling operation.
5. Include description of system controllers, dimensions, features, control interfaces and connections, power requirements, and connections.
6. Include description of control software features.
7. Include total refrigerant required and a comprehensive breakdown of refrigerant required by each system installed.
8. Include refrigerant type and data sheets showing compliance with requirements indicated.
9. Indicate location and dimensional requirements for service access.

B. Shop Drawings: For VRF HVAC systems.

1. Include plans, elevations, sections, and mounting or attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams and details of refrigerant piping and tubing showing installation requirements for manufacturer-furnished divided flow fittings. Piping diagrams shall include refrigerant charge calculation based on the refrigerant line lengths shown in the shop drawings. If VRF system submittals are provided prior to piping shop drawings submittals, VRF system calculations must be resubmitted for review again after piping shop drawings have been approved.
5. Include diagrams for power, signal, and control wiring.

C. Additional Design Submittals requirements:
1. Contractor to confirm with the manufacturer, the refrigerant pipe sizing for each system based an approved pipe routing submittal.
2. Include design calculations with corresponding floor plans indicating that refrigerant concentration limits are within allowable limits of ASHRAE 15 and governing codes.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, sections, and details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural floors, roofs and associated members to which equipment, piping, ductwork, cables, and conduit will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Wall-mounted controllers located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.
5. Size and location of access doors and panels installed behind walls and inaccessible ceilings for products installed behind walls and requiring access.
6. Items penetrating finished ceiling including the following:

    a. Luminaires.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Service access panels.

B. Qualification Data:

1. For Installer: Certificate from VRF HVAC system manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.

    a. Training shall be conducted at jobsite with installing crew by factory-certified trainer.

    b. Retain copies of Installer certificates on-site and make available on request.

2. For VRF HVAC system manufacturer: Equipment must be listed on AHRI’s website directory.

C. Product Certificates: For each type of product.

1. AHRI Certificate of Product Ratings

D. Product Test Reports: Where tests are required, for each product, for tests performed by manufacturer and witnessed by a qualified testing agency or a qualified testing agency.

E. Sample Warranties: For manufacturer's warranties.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VRF HVAC systems to include in emergency, operation, and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On CD or DVD, USB media, or approved cloud storage platform, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: Refer to Specification Section 23 41 00 Particulate Air Filtration for Maintenance Material Requirements.

2. Indoor Units: One for each unique size and type installed.
3. Controllers for Indoor Units: One for each unique controller type installed.

1.9 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Nationally recognized manufacturer of VRF HVAC systems and products.
2. Has shipped VRF HVAC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
3. VRF HVAC systems and products that have been successfully tested and in use on at least twenty completed projects of similar size.
4. Having complete published catalog literature, installation, and operation and maintenance manuals for all products intended for use.
5. Has received third-party testing under AHRI Standard 1230 guidelines.
6. Having full-time in-house employees for the following:

a. Product research and development.
b. Product and application engineering.
c. Product manufacturing, testing, and quality control.
d. Technical support for system installation training, startup, commissioning, and troubleshooting of installations.
e. Owner training.

B. Factory-Authorized Service Representative Qualifications:

1. Authorized representative of, and trained by, VRF HVAC system manufacturer.
2. In-place facility located within 20 miles of Project.
3. Demonstrated experience on ten projects of similar complexity, scope, and value.

    a. Each person assigned to Project shall have demonstrated experience.

4. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
5. Service and maintenance staff assigned to support Project during warranty period.
6. Local product parts inventory to support ongoing system operation for a period of not less than ten years after Substantial Completion.

C. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.

1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
2. Installer certification shall be valid and current for duration of Project.
3. Retain copies of Installer certificates on-site and make available on request.
4. Each person assigned to Project shall have demonstrated past experience.

    a. Demonstrated past experience with products being installed for period within three consecutive years before time of bid.
    b. Demonstrated past experience on three projects of similar complexity, scope, and value.

5. Installers shall have staffing resources of competent, trained, and experienced full-time employees that are assigned to execute work according to schedule.

D. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.

E. Units shall be tested by a National Recognized Testing Laboratory (NRTL), in accordance with ANSI/UL 1995 – Heating and Cooling Equipment and bear the Listed Mark

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products in a clean and dry place.

B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.

C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.

D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.

1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
3. Do not run units for space heating or cooling or drying out of space or for any other reason during the construction phase of the project while significant dusts are being generated.

E. Replace installed products damaged during construction.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace equipment and components that fail(s) in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures.
b. Faulty operation.
c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.

2. Warranty Period:

a. For Compressor: 10 years from date of Substantial Completion.
b. For Parts, Including Controls: 10 years from date of Substantial Completion.
c. For Labor: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. One of the following:
1. Daikin
2. LG North America
3. Mitsubishi
4. Samsung
5. Hitachi

B. Source Limitations: Obtain products from single source from single manufacturer including, but not limited to, the following:

1. Indoor and outdoor units, including accessories.
2. Controls and software.
3. HRCUs.

4. Refrigerant isolation valves.
5. Specialty refrigerant pipe fittings.

2.2 SYSTEM DESCRIPTION

A. Direct-expansion (DX) VRF HVAC system(s) with variable capacity in response to varying cooling and heating loads. System shall consist of multiple indoor units, HRCUs, outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.

1. Maximum system refrigerant volume as specified on the drawings.
2. System(s) operation, air-conditioning heat pump or heat recovery as indicated on Drawings.
3. Each system with one refrigerant circuit shared by all indoor units connected to system.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. AHRI Compliance: System and equipment performance certified according to AHRI 1230 and products listed in AHRI directory**.**

D. ASHRAE Compliance:

1. ASHRAE 15: For safety code for mechanical refrigeration.

2. ASHRAE 34: For safety classification of refrigerants
3. ASHRAE 62.1: For indoor air quality.
4. ASHRAE 135: For control network protocol with remote communication.
5. ASHRAE/IES 90.1 Compliance: For system and component energy efficiency.

E. UL Compliance: Comply with UL 1995.

2.3 PERFORMANCE REQUIREMENTS

A. Service Access:

1. Provide and document service access requirements.
2. Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations. Avoid locations that are difficult to access if possible.
3. Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.
4. If less than full and unrestricted access is provided, locate components within an 18-inch (450-mm) reach of the finished assembly.
5. Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.

6. Comply with OSHA regulations.

B. System Design and Installation Requirements:

1. Design and install systems indicated according to manufacturer's recommendations and written instructions.
2. Where manufacturer's requirements differ from requirements indicated, contact Architect for direction. The most stringent requirements should apply unless otherwise directed in writing by Architect.

C. Isolation of Equipment: Provide isolation valves to isolate each HRCU**,** indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.

D. System Capacity Ratio: The sum of connected capacity of all indoor units shall be within the following range of outdoor-unit rated capacity:

1. Not less than 50 percent.
2. Not more than 200 percent.

E. System Turndown: Stable operation down to 20 percent of outdoor-unit capacity.

F. Outdoor Conditions:

1. Suitable for outdoor ambient conditions encountered.
   a. Provide corrosion-resistant coating for components and supports where located in coastal or industrial climates that are known to be harmful to materials and finishes.

2. Maximum System Operating Outdoor Temperature: See Drawings.
3. Minimum System Operating Outdoor Temperature: See Drawings.

G. Sound Performance: Sound levels generated by operating HVAC equipment shall be within requirements indicated.

1. Indoor: Within design guidelines of "2015 ASHRAE HANDBOOK- HVAC Applications."
2. Outdoor: Within ordinance of governing authorities

H. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.

I. Capacities and Characteristics: As indicated on Drawings.

J. Ability to reset subcooling/superheat target.

K. Ability to reset refrigerant target.

2.4 INDOOR UNITS – DUCTED (CEILING-MOUNTED)

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

B. Cabinet:

1. Material: Galvanized steel.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
4. Mounting: Manufacturer-designed provisions for field installation.
5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Galvanized steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
3. Condensate Overflow Protection: Provide high-level condensate safety shutoff and alarm.
4. Field Piping Connection: Non-ferrous material.

E. Fan and Motor Assembly:

1. Fan(s):

a. Direct-drive arrangement.
b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
c. Fabricated from non-ferrous components or ferrous components with corrosion-resistant finish.

d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.
2. Minimum Efficiency (Ceiling-Mounted Units): ASHRAE 52.2, MERV 14, unless otherwise noted on drawings.
3. Provide accessory filter kit and/or filter box if necessary, to provide the required MERV 14 rating.
4. Media:

a. Replaceable (Ceiling-Mounted Units): Extended surface, panel, or cartridge with antimicrobial treatment fiber media.

G. Unit Accessories:
1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

H. Unit Controls:

1. Enclosure: Metal, suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

a. Unit inlet air temperature.
b. Coil entering refrigerant temperature.
c. Coil leaving refrigerant temperature.

4. Field-Customizable I/O Capability:
a. Digital Inputs: One.

5. Features and Functions:

a. Self-diagnostics.
b. Time delay.
c. Auto-restart.
d. External static pressure control.
e. Auto operation mode.
f. Manual operation mode.
g. Filter service notification.

h. Power consumption display.
i. Drain assembly high water level safety shutdown and notification.
j. Run test switch.

6. Communication: Network communication with other indoor and outdoor units.
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Electrical:

1. Enclosure: Metal, suitable for indoor locations.
2. Field Connection: Single point connection to power unit and integral controls.
3. Disconnecting Means: Field-installed circuit breaker or switch.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

2.5 INDOOR UNITS – DUCTLESS (WALL-MOUNTED, CEILING-MOUNTED CASSETTE)

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.

9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal:
   a. Unit-mounted pump or other integral lifting mechanism for ceiling units, capable of lifting drain water to an elevation above top of cabinet.
   b. Condensate Overflow Protection: Provide high-level condensate safety shutoff and alarm.

3. Field Piping Connection: Non-ferrous material.

E. Fan and Motor Assembly:

1. Fan(s):

   a. Direct-drive arrangement.
   b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
   c. Materials: Non-ferrous components or ferrous components with corrosion-resistant finish.
   d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access:
   a. Bottom for ceiling-mounted units.
   b. Provide access to accommodate filter replacement without the need for tools.
2. Media:
   a. Washable for ceiling-suspended units. Manufacturer's standard filter with antimicrobial treatment.

   b. Replaceable for ceiling-mounted units.
      1) Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
      2) Minimum Efficiency: ASHRAE 52.2, MERV 14, unless otherwise noted on drawings.
      3) Provide accessory filter kit and/or filter box if necessary, to provide the required MERV 14 rating.

G. Discharge-Air Grille Assembly: Manufacturer's standard discharge grille with field-adjustable air pattern mounted in unit cabinet.

1. For Ceiling-Mounted Units:
   a. Discharge Pattern: One-, two-, three-, or four-way throw as indicated on Drawings.

   b. Discharge Pattern Adjustment: Field-adjustable limits for up and down range of motion.
   c. Discharge Pattern Closure: Ability to close individual discharges of units with multiple patterns.
   d. Motorized Vanes: Modulating up and down flow pattern for uniform room air distribution.
   e. Additional Branch Supply Duct Connection: Sheet metal knockout for optional connection to one additional supply branch duct.

H. Return-Air Grille Assembly for Ceiling-Mounted Units: Manufacturer's standard grille mounted in bottom of unit cabinet.

I. Unit Accessories:

1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

J. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

   a. Unit inlet air temperature.
   b. Coil entering refrigerant temperature.
   c. Coil leaving refrigerant temperature.

4. Field-Customizable I/O Capability:
   a. Digital Inputs: One.

5. Features and Functions:

   a. Self-diagnostics.
   b. Time delay.
   c. Auto-restart.
   d. External static pressure control.
   e. Auto operation mode.
   f. Manual operation mode.
   g. Filter service notification
   h. Power consumption display.
   i. Drain assembly high water level safety shutdown and notification.

j. Run test switch.

6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

K. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Field-installed circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

2.6 OUTDOOR, AIR-SOURCE CONDENSING UNITS – 3 PHASE POWER (HEAT PUMP AND/OR HEAT RECOVERY)

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1. Provide heat pump units as designated on Drawings.

2. Heat Pump Units are specially designed for use in systems with either all heating or all cooling demands, but not for use in systems with simultaneous heating and cooling.

3. Heat Recovery Units are specially designed for use in systems with simultaneous heating and cooling.
4. Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
5. All units installed shall be from the same product development generation.

B. Cabinet:

1. Galvanized steel and coated with a corrosion-resistant finish.

a. Coating with documented salt spray test performance of 1000 hours according to ASTM B 117 surface scratch test (SST) procedure.

2. Mounting: Manufacturer-designed provisions for field installation.
3. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Compressor and Motor Assembly:

1. One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive, vapor injection and turndown to 15 percent of rated capacity.
2. Protection: Integral protection against the following:

    a. High refrigerant pressure.
    b. Low oil level.
    c. High oil temperature.
    d. Thermal and overload.
    e. Voltage fluctuations.
    f. Phase failure and phase reversal.
    g. Short cycling.

3. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
4. Vibration Control: Integral isolation to dampen vibration transmission.
5. Oil management system to ensure safe and proper lubrication over entire operating range.
6. Crankcase heaters with integral control to maintain safe operating temperature.
7. Fusible plug.

D. Condenser Coil Assembly:

1. Plate Fin Coils:

    a. Casing: Aluminum, galvanized, or stainless steel.
    b. Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
    c. Tubes: Copper, of diameter and thickness required by performance.

    d. Hydrophylic coating with documented salt spray test performance of 1000 hours according to ASTM B 117 surface scratch test (SST) procedure.

2. Corrosion Protection: Coating with documented salt spray test performance of 1000 hours according ASTM B 117 surface scratch test (SST) procedure.
3. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

E. Condenser Fan and Motor Assembly:

1. Fan(s): Propeller type.

    a. Direct-drive arrangement.
    b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
    c. Statically and dynamically balanced.

2. Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.
3. Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.
4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
5. Speed Settings and Control: Variable speed with a speed range of least 75 percent.
6. Vibration Control: Integral isolation to dampen vibration transmission.

F. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection. Provide a dedicated hot gas refrigerant circuit at bottom of condenser coil used to cool inverter so that no auxiliary drain pan heater is required. If there is no a dedicated inverter cooling circuit, condensing unit will require aux drain pan heater.

G. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

    a. Refrigerant suction temperature.
    b. Refrigerant discharge temperature.
    c. Outdoor air temperature.
    d. Refrigerant high pressure.
    e. Refrigerant low pressure.
    f. Oil level.

4. Features and Functions:
    a. Self-diagnostics,
    b. time delay,
    c. auto-restart,
    d. fuse protection,
    e. auto operation mode,
    f. manual operation mode,
    g. night setback control,
    h. run test switch
    i. equalize run time between multiple same components
5. Communication: Network communication with indoor units and other outdoor unit(s).
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

H. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.

3. Disconnecting Means: Field-installed circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevention corrosion when exposed to salt spray test for 1000 hours according ASTM B 117.

J. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.7 HEAT RECOVERY CONTROL UNITS (HRCUs or BSBs)

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1. Specially designed for use in systems with simultaneous heating and cooling.
2. Systems shall consist of one unit, or multiple unit that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.

B. Cabinet:

1. Galvanized-steel construction.
2. Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.

D. Refrigeration Assemblies and Specialties:

1. Specially designed by manufacturer for type of VRF HVAC system being installed, either two or three pipe.
2. Each refrigerant branch circuit shall have refrigerant control valve(s) to control refrigerant flow.

3. Spares: Each heat recovery control unit shall include at least one branch circuit port(s) for future use.
4. Each system piping connection upstream of heat recovery unit shall be fitted with an isolation valve to allow for service to any heat recovery control unit in the system without interrupting operation of the system.
5. Each branch circuit connection shall be fitted with an isolation valve and capped service port to allow for service to any individual branch circuit without interrupting operation of the system.

    a. If not available as an integral part of the heat recovery control unit, isolation valves shall be field installed adjacent to the unit pipe connection.

E. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:
4. Features and Functions:
    a. Self-diagnostics,
    b. fuse protection,
5. Communication: Network communication with indoor units and outdoor unit(s).
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

F. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

G. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.8 SYSTEM CONTROLS

A. General Requirements:

1. Network: Indoor units**,** HRCUs, and outdoor units shall include integral controls and connect through a manufacturer-selected control network.
2. Network Communication Protocol: Manufacturer-proprietary control communication between interconnected units.
3. Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:

    a. Ethernet connection via RJ-45 connectors and port with transmission at 100 Mbps or higher.
    b. Integration devices shall be connected to local uninterruptible power supply unit(s) to provide at least 5 minutes of battery backup operation after a power loss.
    c. Integration shall include control, monitoring, and scheduling.

4. Operator Interface:

    a. Operators shall interface with system and unit controls through the following:

        1) Operator interfaces integral to controllers.
        2) Owner-furnished PC connected to central controller(s).
        3) Web interface through web browser software.
        4) Integration with Building Automation System.

    b. Users shall be capable of interface with controllers for indoor units control to extent privileges are enabled. Control features available to users shall include the following:

        1) On/off control.
        2) Temperature set-point adjustment.

B. Central Controllers:

1. Centralized control for all indoor and outdoor units from a single central controller location.

    a. Include multiple interconnected controllers as required.

2. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
3. Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.

    a. Sets schedule for daily, weekly, and annual events.

b. Schedule options available through central controller shall at least include the schedule options of controllers for indoor units.

4. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
5. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
6. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
7. Service diagnostics tool.
8. Able to disable and enable operation of individual controllers for indoor units.
9. Information displayed on individual controllers shall also be available for display through central controller.
10. Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.
11. Operator interface through a backlit, high-resolution color display touch panel.

C. Wired Controllers for Indoor Units:

1. Single controller capable of controlling multiple indoor units as group.
2. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
3. Multiple Language: English
4. Temperature Units: Fahrenheit
5. On/Off: Turns indoor unit on or off.
6. Hold: Hold operation settings until hold is released.
7. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
8. Temperature Display: 1-degree increments.
9. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between
10. Fan Speed Setting: Select between available options furnished with the unit.
11. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
12. Seven-day programmable operating schedule with up to eight events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
13. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
14. Occupancy detection.
15. Service Notification Display: "Filter"
16. Service Run Tests: Limit use by service personnel to troubleshoot operation.
17. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
18. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
19. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
20. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

D. Wireless Controllers for Indoor Units (if required):

1. Wireless Communication:

a. Third-Party controller communicates to remote-mounted receiver that is wired to indoor unit(s).

1) Include receivers with wireless controllers as required to complete installation.
2) Low-voltage power required for receivers shall be powered through non-polar connections to indoor unit.

b. One wireless controller shall be capable of communicating with one or multiple receivers to control one or multiple indoor units as a group.

2. Controller Battery Life: Three years.
3. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
4. Language: English
5. Temperature Units: Fahrenheit.
6. On/Off: Turns indoor unit on or off.
7. Hold: Hold operation settings until hold is released.
8. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
9. Temperature Display: 1-degree increments.
10. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments
11. Relative Humidity Display: 1 percent increments.
12. Relative Humidity Set-Point: Adjustable in 1 percent increments
13. Fan Speed Setting: Select between available options furnished with the unit.
14. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
15. Seven-day programmable operating schedule with up to eight events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
16. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
17. Occupancy detection.
18. Service Notification Display: "Filter"
19. Service Run Tests: Limit use by service personnel to troubleshoot operation.
20. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
21. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
22. Setting stored in non-volatile memory to ensure that settings are not lost if power is lost. Battery for date and time only.

2.9 SYSTEM REFRIGERANT AND OIL

A. Refrigerant:

1. As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.
2. ASHRAE 34, Class A1 refrigerant classification.
3. R-410a

B. Oil:

1. As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

2.10 SYSTEM CONDENSATE DRAIN PIPING

A. Comply with requirements in Section 23 21 13 "Hydronic Piping" for system piping requirements.

2.11 SYSTEM REFRIGERANT PIPING

A. Comply with requirements in Section 23 23 00 "Refrigerant Piping" for system piping requirements.

B. Divided-Flow Specialty Fittings: Where required by VRF HVAC system manufacturer for proper system operation, VRF HVAC system manufacturer shall furnish specialty fittings with identification and instructions for proper installation by Installer.

C. Refrigerant Isolation Ball Valves:

1. Description: Uni-body full port design, rated for maximum system temperature and pressure, and factory tested under pressure to ensure tight shutoff. Designed for valve operation without removing seal cap.
2. Seals: Compatible with system refrigerant and oil. Seal service life of at least 20 years.
3. Valve Connections: Flare or sweat depending on size.

2.12 PIPING AND TUBING INSULATION

A. Comply with requirements in Section 23 07 19 "HVAC Piping Insulation" for system piping insulation requirements.

2.13 SYSTEM CONTROL CABLE

A. Cable Rating: Listed and labeled for application according to NFPA 70.

1. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.

    a. Flame Travel Distance: 60 inches (1520 mm) or less.
    b. Peak Optical Smoke Density: 0.5 or less.
    c. Average Optical Smoke Density: 0.15 or less.

2. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
3. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

B. Low-Voltage Control Cabling:

1. Paired Cable: NFPA 70, Type CMG.

    a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
    b. PVC insulation.
    c. Braided or foil shielded.
    d. PVC jacket.
    e. Flame Resistance: Comply with UL 1685.
2. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

    a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
    b. PVC insulation.
    c. Braided or foil shielded.
    d. PVC jacket.
    e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
    f. Flame Resistance: Comply with NFPA 262.

C. TIA-485A Network Cabling:

1. Standard Cable: NFPA 70, Type CMG.

    a. Paired, one pair twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
    b. PVC insulation.
    c. Unshielded.
    d. PVC jacket.
    e. Flame Resistance: Comply with UL 1685.
2. Plenum-Rated Cable: NFPA 70, Type CMP.

    a. Paired, one pair No. 22 AWG, stranded (7x30) tinned-copper conductors.
    b. Fluorinated ethylene propylene insulation.

c. Unshielded.
d. Fluorinated ethylene propylene jacket.
e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
f. Flame Resistance: NFPA 262.

D. Ethernet Network Cabling: TIA-568-C.2 Category 6 cable with RJ-45 connectors.

1. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of category cable indicated.
2. Conductors: 100-ohm, 23 AWG solid copper.
3. Shielding: Unshielded twisted pairs (UTP) or Shielded twisted pairs (FTP).
4. Cable Rating: By application.
5. Jacket: White, Gray, Blue, or Yellow thermoplastic.

E. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems" for control wiring and cable raceways.

2.14 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect factory-assembled equipment.

B. Equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports for historical record. Submit reports only if requested.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine products before installation. Reject products that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.

D. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.

E. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.

F. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.

G. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

H. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION, GENERAL

A. Clearance:

1. Maintain manufacturer's recommended clearances for service and maintenance.
2. Maintain clearances required by governing code.

B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.

3.3 INSTALLATION OF INDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch (10 mm).

C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.

D. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.

E. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.

F. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.

G. Provide lateral bracing if needed to limit movement of suspended units to not more than 0.25 inch (13 mm).

H. For wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.

3.4 INSTALLATION OF OUTDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Install outdoor units on support structures indicated on Drawings.

C. Pad-Mounted Installations: Install outdoor units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete" or Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."

1. Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.
2. Grouting: Place grout under equipment supports and make bearing surface smooth.

D. Roof-Mounted Installations: Install outdoor units on equipment supports specified in Section 07 72 00 "Roof Accessories." Anchor units to supports with removable, stainless-steel fasteners.

3.5 GENERAL REQUIREMENTS FOR PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping and tubing to permit valve servicing.

F. Install piping and tubing at indicated slopes.

G. Install piping and tubing free of sags.

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

I. Install piping and tubing to allow application of insulation.

J. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.

K. Install sleeves for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

3.6 INSTALLATION OF SYSTEM CONDENSATE DRAIN PIPING

A. General Requirements for Drain Piping and Tubing:

1. Install a union in piping at each threaded unit connection.
2. Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
3. If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:

    a. Details indicated on Drawings.
    b. Manufacturer's requirements.
    c. Governing codes.
    d. In the absence of requirements, comply with requirements of ASHRAE handbooks.

4. Extend drain piping from units with drain connections to drain receptors as indicated on Drawings. If not indicated on Drawings, terminate drain connection at nearest accessible location that is not exposed to view by occupants.
5. Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.

B. Gravity Drains:

1. Slope piping from unit connection toward drain termination at a constant slope of not less than one percent.

C. Pumped Drains:

1. If unit condensate pump or lift mechanism is not included with an integral check valve, install a full-size check valve in each branch pipe near unit connection to prevent backflow into unit.

3.7 INSTALLATION OF HYDRONIC PIPING

A. Comply with requirements for hydronic pipe and tubing specified in Section 23 21 13 "Hydronic Piping."

B. Comply with requirements for hydronic specialties specified in Section 23 21 16 "Hydronic Piping Specialties."

C. Install continuous-thread hanger rods and hangers of size required to support equipment weight.
1. Comply with requirements for hangers and supports specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."

D. Where installing piping and tubing adjacent to equipment, allow space for service and maintenance.

3.8 INSTALLATION OF REFRIGERANT PIPING

A. Refrigerant Tubing Kits:

1. Unroll and straighten tubing to suit installation. Deviations in straightness of exposed tubing shall be unnoticeable to observer.
2. Support tubing using hangers and supports indicated at intervals not to exceed 5 feet (1.5 m). Minimum rod size, 1/4 inch (6.4 mm).
3. Prepare tubing ends and make mating connections to provide a pressure tight and leak-free installation.

B. Install refrigerant piping according to ASHRAE 15 and governing codes.

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

D. Install piping as short and direct as possible, with a minimum number of joints and fittings.

E. Arrange piping to allow inspection and service of equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 08 31 13 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

F. Install refrigerant piping and tubing in protective conduit where installed belowground.

G. Install refrigerant piping and tubing in rigid or flexible conduit in locations where exposed to mechanical damage.

H. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping and tubing as follows:

1. Install horizontal hot-gas discharge piping and tubing with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps to entrain oil in vertical runs.
4. Liquid lines may be installed level.

I. When brazing, remove or protect components that could be damaged by heat.

J. Before installation, clean piping, tubing, and fittings to cleanliness level required by VRF HVAC system manufacturer.

K. Joint Construction:

1. Ream ends of tubes and remove burrs.
2. Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.
3. Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

a. Use Type BCuP (copper-phosphorus) alloy for joining copper fittings with copper tubing.
b. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

3.9 GROUNDING INSTALLATION

A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.

B. For low-voltage control cabling, comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.10 IDENTIFICATION

A. Identify system equipment, piping, tubing, and valves. Comply with requirements for identification specified in Section 23 05 53 "Identification for HVAC Piping and Equipment."

B. Identify system electrical and controls components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

1. Identify each control cable on each end and at each terminal with a number-coded identification tag. Each cable shall have a unique tag.

3.11 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage VRF HVAC system manufacturer's service representative to advise and assist installers; witness testing; and observe and inspect components, assemblies, and equipment installations, including controls and connections.

1. Field service shall be performed by a factory-trained and -authorized service representative of VRF HVAC system manufacturer whose primary job responsibilities are to provide direct technical support of its products.

a. Additional factory-authorized representatives may assist with completion of certain activities only if supervised by manufacturer's employee. A factory-authorized representative shall not provide assistance without manufacturer's employee supervision.

2. Manufacturer shall provide on-site visits during the course of construction at installation milestones indicated. System Installer shall coordinate each visit in advance to give manufacturer sufficient notice to plan the visit.

a. First Visit: Kick-off meeting.
b. Second Visit: At approximately 25 percent completion of system(s).
c. Third Visit: At approximately 50 percent completion of system(s).
d. Fourth Visit: At approximately 75 percent completion of system(s).

e. Fifth Visit: Final inspection before system startup.

3. Kick-off Meeting:

   a. Meeting shall include system Installer and other related trades with sole purpose of reviewing VRF HVAC system installation requirements and close coordination required to make a successful installation.
   b. Meeting shall be held at Project site and scheduled at a mutually agreed to time that occurs before the start of any part of system installation.
   c. Meeting shall cover the following as a minimum requirement:

      1) Review of latest issue of Contract Documents, Drawings, and Specifications, relevant to VRF HVAC systems.
      2) Manufacturer's installation requirements specific to systems being installed.
      3) Review of all relevant VRF HVAC system submittals, including delegated-design submittals.
      4) Required field activities related installation of VRF HVAC system.
      5) Project team communication protocol, contact information, and exchange of responsibilities for each party involved, including manufacturer, supplier, system Installer, and other related trades.

4. Site Visits: Activities for each site visit shall include the following:

   a. Meet with VRF HVAC system Installer to discuss field activities, issues, and suggested methods to result in a successful installation.
   b. Offer technical support to Installer and related trades as related to VRF system(s) being installed.
   c. Review progress of VRF HVAC system(s) installation for strict compliance with manufacturer's requirements.
   d. Advise and if necessary assist Installer with updating related refrigerant calculations and system documentation.
   e. Issue a report for each visit, documenting the visit.

      1) Report to include name and contact information of individual making the visit.
      2) Date(s) and time frames while on-site.
      3) Names and contact information of people meeting with while on-site.
      4) Clearly identify and list each separate issue that requires resolution. For each issue, provide a unique identification number, relevant importance, specific location or equipment identification, description of issue, recommended corrective action, and follow-up requirements needed. Include a digital photo for clarification if deemed to be beneficial.

5. Final Inspection before Startup:

   a. Before inspection, Installer to provide written request to manufacturer stating the system is fully installed according manufacturer's requirements and ready for final inspection.
   b. All system equipment and operating components shall be inspected. If components are inaccessible for inspection, they shall be made accessible before the final inspection can be completed.
   c. Manufacturer shall provide a comprehensive inspection of all equipment and each operating component that comprise the complete system(s). Inspection shall follow a detailed checklist specific to each equipment and operating component.
   d. Inspection reports for indoor units shall include, but not be limited to, the following:

      1) Unit designation on Drawings.
      2) Manufacturer model number.
      3) Serial number.
      4) Network address, if applicable.
      5) Each equipment setting.
      6) Mounting, supports, and restraints properly installed.
      7) Proper service clearance provided.
      8) Wiring and power connections correct.
      9) Line-voltage reading(s) within acceptable range.
      10) Wiring and controls connections correct.
      11) Low-voltage reading(s) within an acceptable range.
      12) Controller type and model controlling unit.
      13) Controller location.
      14) Temperature settings and readings within an acceptable range.
      15) Humidity settings and readings within an acceptable range.
      16) Condensate removal acceptable.
      17) Fan settings and readings within an acceptable range.
      18) Unit airflow direction within an acceptable range.
      19) If applicable, fan external static pressure setting.
      20) Filter type and condition acceptable.
      21) Noise level within an acceptable range.
      22) Refrigerant piping properly connected and insulated.
      23) Condensate drain piping properly connected and insulated.
      24) If applicable, ductwork properly connected.
      25) If applicable, external interlocks properly connected.
      26) Remarks.

   e. Inspection reports for outdoor units shall include, but not be limited to, the following:

      1) Unit designation on Drawings.
      2) Manufacturer model number.
      3) Serial number.
      4) Network address, if applicable.

5) Each equipment setting.
6) Mounting, supports, and restraints properly installed.
7) Proper service clearance provided.
8) Wiring and power connections correct.
9) Line-voltage reading(s) within acceptable range.
10) Wiring and controls connections correct.
11) Low-voltage reading(s) within an acceptable range.
12) Condensate removal acceptable.
13) Noise level within an acceptable range.
14) Refrigerant piping properly connected and insulated.
15) Condensate drain piping properly connected and insulated.
16) Remarks.

f. Installer shall provide manufacturer with the requested documentation and technical support during inspection.
g. Installer shall correct observed deficiencies found by the inspection.
h. Upon completing the on-site inspection, manufacturer shall provide a written report with complete documentation describing each inspection step, the result, and any corrective action required.
i. If corrective action is required by Installer that cannot be completed during the same visit, provide additional visits, as required, until deficiencies are resolved and systems are deemed ready for startup.
j. Final report shall indicate the system(s) inspected are installed according to manufacturer's requirements and are ready for startup.

B. Perform the following tests and inspections with the assistance of manufacturer's service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Refrigerant Tubing Positive Pressure Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than 1.5 times VRF HVAC system operating pressure, but not less than 600 psig (4137 kPa), using dry nitrogen.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of 24 hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.

4. Prepare test report to record the following information for each test:

    a. Name of person starting test, company name, phone number, and e-mail address.
    b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
    c. Detailed description of extent of tubing tested.
    d. Date and time at start of test.
    e. Test pressure at start of test.
    f. Outdoor temperature at start of test.
    g. Name of person ending test, company name, phone number, and e-mail address.
    h. Date and time at end of test.
    i. Test pressure at end of test.
    j. Outdoor temperature at end of test.
    k. Remarks:

5. Submit test reports for Project record.

D. Refrigerant Tubing Evacuation Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of 500 microns.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of one hour(s) with no change.
4. Prepare test report to record the following information for each test:

    a. Name of person starting test, company name, phone number, and e-mail address.
    b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
    c. Detailed description of extent of tubing tested.
    d. Date and time at start of test.
    e. Test pressure at start of test.
    f. Outdoor temperature at start of test.
    g. Name of person ending test, company name, phone number, and e-mail address.
    h. Date and time at end of test.
    i. Test pressure at end of test.
    j. Outdoor temperature at end of test.
    k. Remarks:

5. Submit test reports for Project record.
6. Upon successful completion of evacuation testing, system shall be charged with refrigerant.

E. System Refrigerant Charge:

1. Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.
2. Installer shall charge system following VRF HVAC system manufacturer's written instructions.
3. System refrigerant charging shall be witnessed by system manufacturer's representative.
4. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.

F. Products will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.12 STARTUP SERVICE

A. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.

1. Service representative shall be a factory-trained and -authorized service representative of VRF HVAC system manufacturer.
2. Complete startup service of each separate system.
3. Complete system startup service according to manufacturer's written instructions.

B. Startup checks shall include, but not be limited to, the following:

1. Check control communications of equipment and each operating component in system(s).
2. Check each indoor unit's response to demand for cooling and heating.
3. Check each indoor unit's response to changes in airflow settings.
4. Check each indoor unit**,** HRCU**,** and outdoor unit for proper condensate removal.
5. Check sound levels of each indoor and outdoor units.

C. Installer shall accompany manufacturer's service representative during startup service and provide manufacturer's service representative with requested documentation and technical support during startup service.

1. Installer shall correct deficiencies found during startup service for reverification.

D. System Operation Report:

1. After completion of startup service, manufacturer shall issue a report for each separate system.
2. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
3. Manufacturer shall electronically record not less than two hours of continuous operation of each system and submit with report for historical reference.

a. All available system operating parameters shall be included in the information submitted.

E. Witness:

1. Invite Commissioning Agent to witness startup service procedures.
2. Provide written notice not less than 20 business days before start of startup service.

3.13 ADJUSTING

A. Adjust equipment and components to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.

C. Set field-adjustable switches and circuit-breaker trip ranges according to VRF HVAC system manufacturer's written instructions, and as indicated.

D. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.14 PROTECTION

A. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.

B. Protect equipment from physical damage. Replace equipment with physical damage that cannot be repaired to new condition. Observable surface imperfections shall be grounds for removal and replacement.

C. Protect equipment from electrical damage. Replace equipment suffering electrical damage.

D. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.

3.15 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by manufacturer's authorized service representative. Include three service visits for preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment and system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.16 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.17 DEMONSTRATION

A. Engage a VRF HVAC system manufacturer's factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain entire system.

B. Instructor:

1. Instructor shall be factory trained and certified by VRF HVAC system manufacturer with current training on the system(s), equipment, and controls that are installed.
2. Instructor's credentials shall be submitted for review by Commissioning Agent before scheduling training.
3. Instructor(s) primary job responsibility shall be Owner training.
4. Instructor(s) shall have not less than three years of training experience with VRF HVAC system manufacturer and past training experience on at least three projects of comparable size and complexity.

C. Schedule and Duration:

1. Schedule training with Owner at least 20 business days before first training session.
2. Training shall occur before Owner occupancy.
3. Training shall be held at mutually agreed date and time during normal business hours.
4. Each training day shall not exceed eight hours of training. Daily training schedule shall allow time for one-hour lunch period and 15-minute break after every two hours of training.
5. Perform not less than 16 total hours of training.

D. Location: Owner shall provide a suitable on-site location to host classroom training.

E. Training Attendance: For record purposes, document training attendees at the start of each new training session. Record attendee's name, signature, phone number, and e-mail address.

F. Training Format: Individual training modules shall include classroom training followed by hands-on field demonstration and training. Include 8 hours of on-site and 8 hours of classroom training.

G. Training Materials: Provide training materials in electronic format to each attendee.

1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
2. Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.

H. Acceptance: Obtain Commissioning Agent and Owner written acceptance that training is complete and requirements indicated have been satisfied.

END OF SECTION 23 81 29

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SECTION 23 82 39.19 - WALL AND CEILING HEATERS (ELECTRIC)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes wall and ceiling heaters with propeller fans and electric-resistance heating coils.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.

2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

3. Include details of anchorages and attachments to structure and to supported equipment.

4. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.

5. Wiring Diagrams: Power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wall and ceiling unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide product of manufacturer scheduled on drawings or one of the following:

1. Qmark

2. Indeeco

3. Trane
4. Markel Products
5. Chromalox
6. Berko

B. General

1. Incremental wall or ceiling mounted with factory-finished enclosure fans, motors, coils and grille.
2. Heating Medium; Resistance electric
3. Mounting configuration; Wall (surface), Wall (recessed), Ceiling (surface) and Ceiling (recessed).
4. Unit shall be UL listed

C. Enclosure

1. Heavy duty steel with removable front panels fastened with tamperproof fasteners
2. Stamped-steel grille or extruded aluminum bar grille (18 gauge) as scheduled on drawings
3. Design for surface mounting or recessed mounting as schedule on drawings
4. Factory finished with a baked enamel paint over manufacturer's standard prime coating. Finished color selected by Architect from manufacturer's standard colors.
5. Surface mounting box (color to match front panel)
6. Recessed trim kit for recessed units as required

D. Coils

1. Capacity as scheduled on drawings
2. Coil design; Resistance type nichrome elements with open wire design or industrial grade finned sheathed tubular elements per manufacturers standard design concept
3. Heating elements shall terminate in a terminal box
4. Heating element design shall be free from expansion, noise and 60Hz hum
5. Electrical Input; See schedule on drawings for heater voltage and phase requirements.
6. Single point of electrical connection for both heating elements and fan

7. Disconnect/contactor

8. Automatic thermal reset cut-out

9. Transformer Voltage as required for unit size (fused on secondary and grounded

10. Fan interlocked with heating coil to prevent coil from being activated with fan not running.

11. Heater shall be complete with electrical components, devices, accessories, etc required for full compliance with the latest edition of the National Electric Code and State and Local authorities having jurisdiction.

E. Fan

1. Propeller type arranged for draw-thru air flow design to provide uniform air movement over entire heating element surface.

2. Aluminum blades mounted on hub

3. Fan wheel directly mounted to motor shaft

F. Motor

1. Manufacturers standard design permanently lubricated and thermally protected

2. See Division 23; Section titled "Common Motor Requirements for HVAC Equipment" for additional requirements

G. Electrical Components, Devices, Accessories; Listed and labeled as defined in latest edition of NFPA 70 by a qualified testing agency and marked for intended location and application.

H. Controls; Factory wired unit mounted (with plug for tamperproof installation) or wall mounted thermostat as scheduled on drawings. Heater manufacturer to provide wall mounted thermostat (line or low voltage as required for heater wiring.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive wall and ceiling heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

D. For recessed units, coordinate wall and/or ceiling opening required for heater with Contractor responsible wall or ceiling construction.

3.2 INSTALLATION

A. Install wall and ceiling unit heaters to comply with NFPA 90A.

B. Install wall and ceiling unit heaters level and plumb.

C. For heaters with wall thermostat, install heater in wall electrical box at a height required to meet American with Disabilities Act, Fair Housing Act or other Federal, State and Local codes having jurisdiction. Wiring between thermostat and heater shall be in metallic conduit

D. Wiring to comply with applicable Sections of Division 26

END OF SECTION 23 82 39.19

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SECTION 23 83 23.16 - RADIANT-HEATING ELECTRIC MATS

NVENT NUHEAT MAT FLOOR HEATING SYSTEM

PART 1 GENERAL

1.1 SUMMARY

A. Section includes UL Listed and CSA Certified floor heating systems.

1.2 REFERENCES

A. Reference Standards
1. UL515 – Electrical Resistance Heat Tracing for Commercial Applications
2. IEEE 515.1-2012 Standard for the Testing, Design, Installation & Maintenance of Electric Resistance Trace Heating for Commercial Applications.
3. CSA Standard C22.2 No. 130-03 Requirements for Electrical Resistance Heating Cables & Heating Device Sets
4. NFPA 70 - National Electrical Code
5. CSA Standard C22.1 – Canadian Electrical Code
6. AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI—current edition)
7. UL 1693, Second Edition
8. UL 1683, Issue No. 2
9. NEC Article 424 Floor Warming Systems
10. AMERICAN SOCIETY for TESTING & MATERIALS (ASTM—current edition)

1.3 SYSTEM DESCRIPTION

A. System Description: Electric radiant floor heating system consisting of a resistance heating wire bonded in a pre-configured pattern between two porous layers of fabric and thermostat(s) with built-in Class A GFCI protection.
1. The pre-formed electric floor heating product is manufactured to fit the shape of the heated floor area, without the need for on-site alterations or configuration, to ensure evenly distributed warmth throughout the heated floor area.
2. Heating product thickness shall not exceed 1/8 inch (3.2 mm).
3. The heating products must be protected by a minimum, non-pro-rated, 25-year warranty.
4. This system must be approved for use under ceramic tile, marble, other natural stone, laminate, engineered wood, and luxury vinyl floor coverings.
5. Thermostat must have built-in class A GFCI protection, floor sensing and ambient air sensing capabilities.

6. Thermostat must work with Amazon Alexa, Google Assistant, Google Nest, IFTTT, Control4, and/or other custom integrations using thermostat manufacturer's Open API.

1.4 ACTION SUBMITTALS / INFORMATIONAL SUBMITTALS

A. Product Data
   1. Floor heating data sheet
   2. UL Listed certificates for floor heating
   3. System installation and operation instructions
   4. System installation details
   5. Thermostat data sheet
   6. Thermostat wiring diagram

B. Shop Drawings
   1. Detailed engineered drawings showing layout(s) of the floor.

1.5 QUALITY ASSURANCE

A. Source Limitations
   1. All system components (heating products, thermostats, and any other accessories) shall be sourced from a single manufacturer and under no circumstances shall components be installed other than those supplied by the system manufacturer to ensure system integrity and meet warranty requirements.

B. Qualifications
   1. Manufacturers
      a. Manufacturer must have a minimum of thirty (30) years of experience in manufacturing floor heating systems.
      b. Manufacturer must be ISO-9001 registered.
      c. Manufacturer must provide floor heating product that meets IEEE 515.1, CSA 22.2 No 130-03, and UL1683 requirements.
   2. Installers
      a. System installer shall have a complete understanding of all relevant products and product literature directly from the manufacturer or from an authorized representative of the manufacturer prior to installation. Electrical connections shall be performed by a licensed electrician or otherwise appropriately qualified electrical contractor.
   3. Labelling of Electrical Components, Devices, and Accessories
      a. All system components (heating products, thermostats, and any other accessories) must be listed and labelled as defined in NFPA 70, Article 100, by a Nationally Recognized Testing Laboratory (NRTL), and marked for intended use.

C. Certifications

a. All system components (heating products, thermostats, and any other accessories) shall be UL Listed and CSA Certified for floor heating.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Delivery And Acceptance Requirements

1. All system components must be delivered, stored, and handled in such a way as to prevent their deterioration or damage due to moisture, temperature changes, contaminates, or other causes.
2. All system components must be delivered to the site in original unopened containers or packages with intact and legible manufacturer's labels and must include the following information:
   a. Product and Manufacturer
   b. Size and Quantity
   c. Lot Number
   d. Installation and Operation Instructions
   e. MSDS (if applicable)

B. Storage And Handling Requirements

1. All system components must be stored in a clean, dry location with a temperature range not below -40°F (-40°C) and not exceeding 140°F (60°C).
2. All system components must be protected from mechanical damage.

1.7 WARRANTY

A. Manufacturer Warranty

1. The manufacturer must warranty all heating products and membranes with a comprehensive, non-prorated written twenty-five (25) year warranty against product defects which covers replacement materials and applies when installed under ceramic tile, marble, other natural stone, laminate, engineered wood, and luxury vinyl floor coverings.
2. The manufacturer must warranty all thermostats with a comprehensive, non-prorated written three (3) year warranty against product defects which covers replacement materials.

B. Installer Warranty

1. This special warranty extends the period of limitations contained in the General Conditions. The installer warranty will be countersigned by the installer and the manufacturer. The installer warrants the work of this section to be in accordance with the Contract Documents and free from faults and defects in materials and workmanship for a period of one (1) year.

PART 2 PRODUCTS

2.1 FLOOR HEATING SYSTEM

A. Manufacturer

1. Basis of Design Manufacturer: Subject to the compliance with requirements, provide nVent NUHEAT floor heating products courtesy of nVent Thermal Management, LLC Richmond, BC

   Phone: 800-778-9276

   Email: RES.customercare@nvent.com

   Website: www.nuheat.com

2. Provide specified product; Owner will not consider substitution requests.

B. Materials

1. Floor Heating Mat(s)
   a. Floor Heating Mat(s) should be shown in the drawings, carefully defining required locations, dimensions, and heights.
   b. Thermostat(s) should be shown in the drawings, carefully defining required location(s).
   c. Where indicated on the drawings and elsewhere as required, provide a heating mat using one of those listed on the "Tested Materials" list of the Underwriter's Laboratory (UL) or the Canadian Standards Association (CSA) or provide a similar system approved in advance by the Architect.
   d. Basis-of-Design Products:
      1) nVent NUHEAT Mat
         a) Electric radiant floor heating system consisting of a resistance heating wire bonded in a pre-configured pattern between two porous layers of fabric.
         b) The pre-formed electric floor heating product is manufactured to fit the shape of the heated floor area, without the need for on-site alterations or configuration, to ensure evenly distributed warmth throughout the floor.
         c) Heating product thickness shall not exceed 1/8 inch (3.2 mm).
         d) The system must be protected by a minimum, non-prorated, 25-year warranty.
         e) The system must be approved for use under ceramic tile, marble, other natural stone, laminate, engineered wood, and luxury vinyl floor coverings.
      2) Controls
         a) Refer to drawings M-502 and M-705 for control intent. Mat manufacturer to provide floor temperature sensor (thermistor) for control by BMS contractor.
         b) Refer to specification section 230910.

2. Approval
   a. All system components shall be UL Listed and CSA Certified for floor heating.
   b. All system components shall come with an installation and operation instructions.

PART 3 EXECUTION

3.1 EXAMINATION

A. Substrate Examination
   1. Verify that subfloor structures to be covered with floor heating product(s) and floor covering materials are sound, conform to accepted design/engineering practices, and are sufficiently rigid with maximum deflection of L/360 distributed uniformly over the span.
   2. Concrete shall be cured a minimum of twenty-eight (28) days at 70°F with a saturated surface dry (SSD) condition, including an initial seven (7) day period of wet curing prior to installation of the floor heating system.
   3. Concrete slab(s) to have steel trowel or light broom finish when floor heating system is to be installed using thin-set mortar.
   4. Substrate must be clean and free of dirt, oil, grease, sealers, curing compounds, form oil, loose plaster, paint, and scale in order to install the floor heating system.

3.2 PREPARATION

A. Examine the areas and conditions under which work described in this section will be performed. Correct conditions detrimental to timely and proper completion of the work. Do not proceed until unsatisfactory conditions are corrected.

B. Coordinate with other trades as needed to assure that proper substrata are provided to receive the work of this section.
   1. Horizontal surfaces shall be level within one quarter of an inch (1/4”) for every ten feet (10’) in all directions.

C. Condition of surfaces to receive floor heating (product(s):
   1. Verify that surfaces to receive mortar setting bed and floor heating product(s) are firm, dry, clean, and free from dust, wax, grease, sealers, and all other contamination which may reduce or prevent adhesion.
   2. Verify that the concrete has been heavily scarified if curing compounds have been used.
   3. Verify that grounds, anchors, plugs, recess frames, bucks, electrical work, mechanical work, and similar items under the floor heating product(s) have been installed before proceeding with the installation of the floor heating product(s).
   4. Advise General Contractor and Architect of any surface or substrate conditions requiring correction before tile work commences. Beginning of work constitutes acceptance of substrate or surface conditions.

3.3 INSTALLERS

A. Acceptable Installers

1. Subject to compliance with requirements of Contract Documents, installer shall have minimum one (1) year documented experience with installations of similar scope, materials, and design.

3.4 INSTALLATION

A. General

1. Comply with pertinent provisions of the referenced standards, except as otherwise directed by the architect or specified herein.
2. Maintain minimum temperature limits and installation practices recommended by materials manufacturers.

B. Do not begin installation of the floor heating product(s) until it has been tested and accepted.

1. To confirm the proper power consumption of the floor heating product(s) and to confirm that there is no short to ground, perform the insulation and resistance test on the ground braid and each conductor wire as per installation instructions provided. Ensure that the resistance reading is within the range of plus 10% to minus 5% of the resistance rating listed on the product tag(s) as per installation instructions provided with the floor heating product(s). Mark the test results on the warranty card provided and ensure they match manufacturer's recorded information on the floor heating product tag(s) as per installation instructions provided with the floor heating product(s). If system does not pass insulation and resistance testing, contact nVent NUHEAT technical services at (800) 778-9276.

C. Install according to TCNA installation methods and written instructions

1. TCNA #RH 130 EGP (Exterior Glue Plywood) Latex-Portland Cement Mortar
2. TCNA #RH 135 Cementitious Backer Units/Fibre Cement Underlayment
3. Floor Warming Systems UL 1693; CSA-C22.2 No.130-03; NEC Article 424

D. Subfloor – 19/32" exterior-glue plywood on joists every 16" on center. Gaps between plywood sheets to be treated per setting material manufacturer's recommendations.

E. Electrical connections shall be performed by a licensed electrician or otherwise appropriately qualified electrical contractor.

F. Apply coat of polymer-modified thinset mortar to the subfloor using a quarter-inch (1/4") square notched trowel. Roll the floor heating mat(s) into the thinset material. Using a grout float, smooth out all air bubbles or folds. Ensure bond between floor heating mat(s) and thinset conforms to at least 80% coverage.

G. Perform a second resistance and insulation test on the floor heating product(s) prior to installation of floor covering products as described above in 3.4 (B) (1). If system does not pass insulation and resistance testing, contact nVent NUHEAT technical services at (800) 778-9276.

H. Route the cold lead wires to the thermostat location and install the thermostat sensor probe wire as described in the installation instructions provided with the floor heating system.

I. Install compatible floor covering materials according to architectural specifications sections.

3.5 CONNECTIONS

A. Ground equipment in accordance with Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Connect wiring in accordance with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.6 PROTECTION

A. Protect finished installation. Close areas to other trades and traffic until floor covering materials has set and/or cured correctly. Keep traffic off horizontal Portland cement thick bed mortar installations for at least seventy-two (72) hours at 70°F (21°C).

B. Replace or restore work of other trades damaged or soiled by work under this section.

END OF SECTION

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