

**SECTION 230000 - GENERAL PROVISIONS FOR HEATING, VENTILATING AND AIR
CONDITIONING WORK**

PART 1 GENERAL

1.1 DEFINITIONS

- A. "Provide": to furnish, install, and make complete, safe, and operable, the particular work referred to unless specifically indicated otherwise.
- B. "Furnish" or "supply": to purchase, procure, acquire, and deliver complete with related accessories.
- C. "Install": to erect, mount, and make complete with related accessories.
- D. "Work": includes labor, materials, equipment, services, and all related accessories necessary for the proper and complete installation for fully functioning and operational systems.
- E. "Piping": includes pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and related accessories.
- F. "Wiring": includes wire, raceway, fittings, boxes, and related accessories.
- G. "Concealed": not in view, installed in masonry or other construction, within furred spaces, double partitions, hung ceilings, trenches, crawl spaces, or enclosures.
- H. "Exposed": in view, not installed underground or "concealed" as defined above.
- I. "Indicated," "shown," or "noted": as indicated, shown or noted on drawings or specifications.
- J. "Similar" or "equal": to base bid manufacturer, equal in quality, materials, weight, size, performance, design and efficiency of specified product, conforming with "Base Bid Manufacturers" as determined and approved by Engineer.
- K. "Approved": satisfactory as reviewed.
- L. "Accepted As Noted": accepted with comments.
- M. "Revise and Resubmit": resubmit with revisions.
- N. "Disapproved": not approved.
- O. "Submit Specified Item": provide specified item directed by Engineer.
- P. "Reviewed": assessed for reference only final approval by others.
- Q. "Substitutions": Changes from Contract Documents requirements proposed by Contractor to materials, products, assemblies, and equipment.

1.2 WORK INCLUDED

- A. The work covered by this section includes the construction described in the Contract Documents, labor necessary to perform and complete such construction, materials and equipment incorporated or to be incorporated in such construction, and services, facilities, tools and equipment necessary or used to perform and complete such construction.
- B. Related Work not Included in this Division but Specified Elsewhere:
 - 1. Requirements of GENERAL CONDITIONS and Division No. 1.
 - 2. Finish painting, except for prefinished equipment or as otherwise specified.
 - 3. Concrete work, except equipment inertia and floating bases.
 - 4. Base flashing for piping, ductwork, etc.
 - 5. Waterproofing.
 - 6. Power wiring for motors and motor controllers.
 - 7. Installation of access doors and frames.

8. Cutting and patching.
9. Excavating and backfilling.
10. Fire alarm wiring.

1.3 DESCRIPTION OF BID DOCUMENTS

- A. Specifications describe quality and character of materials and equipment.
- B. Drawings are diagrammatic and indicate sizes, locations, connections to equipment and methods of installation. Provide additional offsets, fittings, hangers, supports, valves, drains as required for construction and coordination with work of other trades.
- C. Scaled and indicated dimensions are approximate and are for estimate purposes only. Before proceeding with work, check and verify dimensions and field conditions.
- D. Make adjustments that may be necessary or requested in order to resolve space problems, preserve headroom, and avoid architectural openings, structural members and work of other trades.
- E. Typical details, where shown on the drawings, apply to each item of the project where such items are applicable. Typical details are not repeated in full on the plans, and are diagrammatic only, but with the intention that such details shall be incorporated in full.
- F. If any part of Specifications or Drawings appears unclear or contradictory, consult Architect and/or Engineer for interpretation and decision as early as possible during bidding period. Do not proceed with work without the Architect's and/or Engineer's decision.

1.4 COORDINATION OF WORK

- A. The drawings show the general arrangement of equipment, piping, ductwork, and appurtenances. Follow these drawings as closely as the actual construction will permit. Conform the work to the requirements shown on the drawings. Provide offsets, fittings, and accessories which may be required but not shown on the drawings. Investigate the site, structural and finish ground conditions affecting the work, and arrange the work accordingly. Provide such work and accessories as may be required to meet such conditions.
- B. Certain materials will be provided under other Sections of work. Examine the Contract Documents to ascertain these requirements.
- C. Carefully check space requirements with other Sections to insure that all material can be installed in the spaces allotted thereto including finished suspended ceilings.
- D. Transmit to other Sections all information required for work to be provided under those Sections, in ample time for installation.
- E. Wherever work interconnects with work specified under other Sections, coordinate those sections of work to insure that all necessary information is presented so that all the necessary connections and equipment may be properly installed. Identify all items (valves, piping, equipment, etc.) in order that access doors and panels can be properly located.
- F. Furnish and set all sleeves for passage of pipes through structural masonry, concrete walls, floors, and elsewhere as required for the proper protection of pipes passing through building surfaces.
- G. Provide required supports and hangers for piping and equipment, designed so as not to exceed allowable loadings of structures.
- H. Examine and compare the contract drawings and specifications with the drawings and specifications of other disciplines, and report any discrepancies between them to the Engineer and obtain from them written instructions for changes necessary in the work of this Section.

Install and coordinate the work of this Section in cooperation with installing interrelated work. Before installation, take proper provisions to avoid interferences. All changes required in the work, caused by their neglect to do so, to be made at no additional expense. Before commencing work, examine all adjoining work on which this work is in any way dependent for perfect workmanship and report any conditions which prevent performance of first class work. Become thoroughly familiar with actual existing conditions to which connections must be made or which must be changed or altered.

- I. Wherever the work is of sufficient complexity, prepare additional detail drawings. Such detailed work is to be clearly identified on the drawings as to the area to which it applies. Submit these drawings to the Engineer for review. At completion, however, include a set of such drawings with each set of as-built drawings. When directed by the Engineer, submit drawings for review, clearly showing the work of this Section and its relation to the work of other disciplines before commencing shop fabrication or erection in the field.
- J. Provide required anchor bolts, sleeves, inserts, and supports designed so as not to exceed allowable loadings of structures. Locate anchors, bolts, sleeves, inserts, and supports to insure that they are properly installed. Any expense resulting from the improper location or installation of anchor bolts, sleeves, inserts and supports to be paid for by the Contractor.
- K. Adjust location of pipes, panels, equipment, etc., to accommodate the work to prevent interferences, both anticipated and encountered. Determine the exact route and location of each pipe prior to fabrication.
 - 1. Right-of-Way: Lines which pitch have the right-of-way over those which do not pitch, i.e., plumbing drains. Lines whose elevations cannot be changed have right-of-way over lines whose elevations can be changed.
 - 2. Make offsets, transitions and changes in direction in pipes as required to maintain proper head room and pitch on sloping lines whether or not indicated on the drawings. Furnish and install all traps, air vents, drains, etc., as required to offset, transition, and change in direction.
- L. Install all mechanical work to permit the removal (without damage to other parts) of equipment requiring periodic replacement or maintenance. Arrange ducts, pipes, and equipment to permit access to valves, cocks, starters, motors, and control components, and to clear the openings of swinging doors and access panels.
- M. Coordinated Composite Drawings
 - 1. The Contractor shall prepare full coordinated composite drawings for the mechanical, electrical, plumbing, and fire protection work. The Contractor shall overlay each discipline's work (in separate colors) on a set of shop drawings. Conflicts and potential conflicts shall be clearly identified. This shall include but not be limited to conflicts with lights, equipment, piping, ductwork and supports of other trades, as well as conflicts with architectural and structural walls, columns, ceilings and structural beams. The contractor shall have representative(s) attend a weekly job site coordination meeting in the field office. All trades shall resolve conflicts at these meetings and sign off each shop drawing indicating acceptance and satisfactory resolution to all conflicts. All conflicts that cannot be resolved shall be brought to the attention of the Engineer for resolution.

1.5 CONTRACTOR'S RESPONSIBILITY FOR EVALUATION

- A. The Contractor shall review all available data on the location and types of underground utilities. The Contractor shall not operate equipment over the utilities and shall take care not to damage them or otherwise impair their use. The Contractor shall make investigation to verify

the location of these utilities before proceeding with construction and/or operations in their vicinity.

- B. The Engineer and Owner make no representations, regarding the character or extent of the subsoils, water levels, existing structural, mechanical, and electrical installations, above or below ground or other subsurface conditions which may be encountered during the work. The contractor must make their own evaluation of existing conditions which may affect methods or cost of performing the work, based on their own examination of the facility or other information. Failure to examine the drawings or other information shall not relieve the contractor of their responsibility for satisfactory accomplishment of the work.
- C. The locations of existing utilities are believed to be as indicated on the plans. The Contractor shall verify the location of these utilities prior to commencing any work and notify the Engineer of any discrepancies.
- D. Inspection of Site Conditions.
 - 1. Before starting work, visit the site and examine the conditions under which the work has to be performed. Report in writing any conditions which might adversely affect the work.
- E. Connections to existing work:
 - 1. Install new work and connect to existing work with minimum interference to existing facilities.
 - 2. Provide temporary shutdowns of existing services at no additional charges and only with written consent of Owner. Schedule shutdowns not to interfere with normal operation of existing facilities.
 - 3. Alarm and emergency systems shall not be interrupted without alternative arrangements.
 - 4. Maintain continuous operation of existing facilities as required with necessary temporary connections between new and existing work.
 - 5. Connect new work to existing work in neat and acceptable manner. Restore existing disturbed work to original condition including maintenance of wiring continuity required.
 - 6. Perform service disconnections only after regular working hours.

1.6 ACCESS TO FIRE PROTECTION EQUIPMENT

- A. The Contractor shall not interfere with access to hydrants, fire exits, fire hose stations, fire extinguishers and fire alarm pull stations. In no case shall the Contractor's material or equipment be within twenty five (25) ft of a hydrant or fire alarm pull station.

1.7 EQUIPMENT AND MATERIALS

- A. If products and materials are specified or indicated on the drawings for a specific item or system, the Contractor shall use those products or materials. If products and materials are not listed in either of the above, use first class products and materials, in accordance with shop drawings.
- B. All products and materials shall be new, clean, free of defects, damage, and corrosion.
- C. No permanent equipment shall be used to provide services during construction.
- D. Ship and store all products and materials in a manner which will protect them from damage, weather, and entry of debris. If items are damaged, do not install, but take immediate steps to obtain replacement or repair.
- E. Make certain that all materials selected directly, or by suppliers, conform to the requirements of the contract drawings and specification. Transmittal of such specifications and drawings, information to persons manufacturing and supplying materials to the project, and rigid adherence thereto, is the Contractor's responsibility. Acceptance of a manufacturer's name by

the Engineer does not release the Contractor of the responsibility for providing materials which comply in all respects with the requirements in the Contract Documents.

- F. Applicable equipment and materials to be listed by Underwriters' Laboratories (UL) and manufactured in accordance with ASME, AWWA, or ANSI standards, and as approved by local authorities having jurisdiction.
- G. Fully lubricate all equipment when installed and prior to final acceptance.
- H. Do not put systems in operation until piping and ductwork has been tested and cleaned.
- I. Follow manufacturers' instructions for installing, connecting, and adjusting all equipment. Provide one copy of such instructions to the Engineer before installing any equipment. Provide a copy of such instructions at the equipment.

1.8 SUBSTITUTIONS

- A. Substitution limitations:
 - 1. Products specified by Reference Standards or by description only: Use any product meeting those standards or description.
 - 2. Products specified by naming one or more manufacturers with a provision for substitutions: Submit a request for substitution for any manufacturer or model not named.
 - 3. Products specified by naming one manufacture's model number:
No substitutions accepted after procurement.
- B. A Substitution Request for products, assemblies, materials, and equipment constitutes a representation that the submitter:
 - 1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product, equipment, assembly, or system.
 - 2. Agrees to provide the same warranty for the substitution as for the specified product.
 - 3. Agrees to provide same or equivalent maintenance service and source of replacement parts, as applicable.
 - 4. Agrees to coordinate installation and make changes to other work that may be required for the work to be complete, with no additional cost to Owner.
 - 5. Waives claims for additional costs or time extension that may subsequently become apparent.
 - 6. Agrees to reimburse Owner and design team for review or redesign services associated with re-approval by authorities.
- C. Document each request with complete data substantiating compliance of proposed substitution with Contract Documents. Burden of proof is on proposer.
 - 1. Note explicitly any non-compliant characteristics.
 - 2. Savings to Owner for accepting substitution.
 - 3. Change to Contract Time due to accepting substitution.
- D. Substitution Procedures During Procurement
 - 1. Submit substitution requests by completing CSI/CSC Form 1.5C - Substitution Request (During the Bidding/Negotiating Stage). See this form for additional information and instructions. Use only this form; other forms of submission are unacceptable.
 - 2. Owner and Engineer will consider requests for substitutions only if submitted at least 10 days prior to the date for receipt of bids.
- E. Substitution Procedures During Construction

1. Submit substitution requests by completing CSI/CSC Form 13.1A - Substitution Request. See this form for additional information and instructions. Use only this form; other forms of submission are unacceptable.
2. Submit request for Substitution for Cause within 14 days of discovery of need for substitution, but not later than 14 days prior to time required for review and approval by Engineer, in order to stay on approved project schedule.
3. Submit request for Substitution for Convenience immediately upon discovery of its potential advantage to the project, but not later than 14 days prior to time required for review and approval by Engineer, in order to stay on approved project schedule.

F. Resolution

1. Engineer may request additional information and documentation prior to rendering a decision. Provide this data in an expeditious manner.
2. Engineer will notify Contractor in writing of decision to accept or reject substitution request. Engineer's decision following review of proposed substitution will be noted on the submitted form.

1.9 QUALITY ASSURANCE

- A. All equipment and accessories shall be the product of manufacturers regularly engaged in their manufacture. All items of a given type shall be the products of the same manufacturer.
- B. Furnish all equipment and accessories new and free from defects.
- C. All electrical equipment shall be listed by Underwriters' Laboratories, Inc. (UL) or bear UL labels.
- D. Supply all equipment and accessories in complete compliance with and in accordance with the applicable standards listed in reference standards of this Section and with all applicable national, state and local codes.

1.10 JOB CONDITIONS

- A. Inspection of Site Conditions:
 1. Before starting work, visit the site and examine the conditions under which the work has to be performed. Report in writing any conditions which might adversely affect the work.
- B. Connections to existing work:
 1. Install new work and connect to existing work with minimum interference to existing facilities.
 2. Provide temporary shutdown of existing services at no additional charges and only with written consent of Owner. Schedule shutdowns not to interfere with normal operation of existing facilities.
 3. Maintain continuous operation of existing facilities as required with necessary temporary connections between new and existing work.
 4. Connect new work to existing work in neat and acceptable manner. Restore existing disturbed work to original condition.
- C. Removal and relocation of existing work.
 1. Disconnect, remove, or relocate mechanical material, equipment, and other work noted and required by alterations, modifications, or changes in existing construction.
 2. Provide new material and equipment required for relocated equipment.
 3. Plug or cap active piping or ductwork behind or below finish.
 4. Dispose of removed mechanical equipment as directed.

1.11 CLEARANCE FROM ELECTRICAL EQUIPMENT

- A. Piping and ductwork is prohibited in electric and telephone rooms and closets, elevator machine rooms, and for installations over or within 5 ft of transformers, substations, switchboards, motor control centers, standby power plants, and motors.
- B. Branch piping to equipment is acceptable when installed over or within 5 ft of motors.
- C. Provide drip pans under all water and drainage piping when installation over or within 5 ft of electrical apparatus is unavoidable or in rooms containing electrical equipment. Pan shall be reinforced, properly supported and made watertight. Provide enclosed type for pressure piping. Extend 1-1/4 in. drain pipe from pan to spill over nearest floor drain or as indicated on drawings.
 - 1. Construction shall be 18 gauge galvanized sheet steel.

1.12 SHOP DRAWINGS

- A. Prepare and submit detailed shop drawings for piping work and other distribution services, including locations and sizes of all openings in floor walls and roofs.
- B. The work described in any shop drawing submission to be carefully checked for all clearances (including those required for maintenance and servicing), field conditions, maintenance of architectural conditions and proper coordination with all trades on the job. Each submitted shop drawing to include a certification that all related job conditions have been checked and that no conflict exists.
- C. All drawings to be submitted sufficiently in advance of field requirements to allow (15) days for checking. All submittals to be complete and contain all required and detailed information. Shop drawings with multiple parts to be submitted as a package.
- D. If submittals differ from the Contract Document requirements, make specific mention of such difference in a letter of transmittal, with request for substitution, together with reasons for same.
- E. Review of any submitted data or shop drawings for material, equipment apparatus, devices, arrangement and layout shall not relieve the Contractor from responsibility of furnishing same of proper dimensions and weight, capacities, sizes, quantity, quality and installation details to efficiently perform the requirements and intent of the Work. Such review shall not relieve the Contractor from responsibility for errors, omissions or inadequacies of any sort on submitted data or shop drawings.
- F. Each shop drawing is to contain the job title, the name and phone numbers of the Contractor, references to the applicable design drawing or specification article, date and scale.
- G. Within three (3) weeks after award of Contract, submit a list of all shop drawings which will be submitted in the course of the project. List to show disposition of each item, including date of submission, review, and the like. List to be kept up-to-date throughout entire construction period.
- H. Submit shop drawings and manufacturer's data for the following items in accordance with the Contract Documents:
 - 1. Coordinated, detailed shop layout drawings of all mechanical rooms, services and distribution systems, including plans, profiles and Sections.
 - 2. Details of piping supports, elbows, anchors and miscellaneous appurtenances.
 - 3. Hangers, supports, inserts, anchors, guides and foundations.
 - 4. Equipment and piping layouts at 3/8 in. scale for the building.

5. Location and size of sleeves for openings in floors and walls.
6. Schedule of pipe and fittings, materials and application, valves, escutcheons, air vents, valve tags and schedules, strainers, and water specialties.
7. Building automation systems including descriptions, instruments, and alarms.
8. Flashing.
9. Equipment identification and certificates.
10. UL listed and tested fire stopping systems with location and type of penetration indicated.
11. Other shop drawings and submittals as requested within the specification.

1.13 START-UP

- A. Properly lubricate all pieces of equipment.
- B. Check and clean all pipes of dirt and debris, including strainers.
- C. Prepare each piece of equipment in accordance with manufacturer's installation instructions and have a copy at the equipment.
- D. Fill and vent all water systems.
- E. Check rotation on each motor.
- F. Have representatives of each manufacturer present when hereinafter specified, so that equipment will be started up by manufacturer.

1.14 PRODUCT, DELIVERY, HANDLING AND STORAGE

- A. Ship materials and equipment in crated sections of sizes to permit passing through available space, where required.
- B. Receive and accept materials and equipment at the site, properly handle, house, and protect them from damage and the weather until installation. Replace equipment damaged in the course of handling without additional charge.
- C. Arrange for and provide storage space or area at the job site for all materials and equipment to be received and/or installed in this project.
- D. Protect from damage, water, dust, etc., materials, equipment and apparatus provided under this trade, both in storage and installed.

1.15 ACCESSIBILITY

- A. Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Minor deviations from the drawings may be made to accomplish this, but changes of substantial magnitude shall not be made without written approval.
- B. Group concealed valves, expansion joints, controls, dampers, and equipment requiring access, so as to be freely accessible through access doors.

1.16 CUTTING AND PATCHING

- A. Provide all cutting and patching required for proper installation of materials and equipment specified. Do not cut or drill structural members without review and written approval by Architect and Structural Engineer.

1.17 GUARANTEE

- A. The Contractor shall furnish a written guarantee to replace or repair promptly and assume responsibility for all expenses incurred for any workmanship and equipment in which defects develop within one year from the date of final certificate for payment and/or from date or actual use of equipment or occupancy of spaces by Owner included under the various parts of

the work, whichever date is earlier. This work shall be done as directed by the Owner. This guarantee shall also provide that where defects occur, the Contractor will assume responsibility for all expenses incurred in repairing and replacing work of other trades affected by defects, repairs or replacements in equipment supplied by the Contractor.

1.18 PERMITS AND FEES

- A. The Contractor shall give necessary notice, file drawings and specifications with the department having jurisdiction, obtain permits or licenses necessary to carry out this work and pay all fees therefore. The Contractor shall arrange for inspection and tests of any or all parts of the work if so required by authorities and pay all charges for same. The Contractor shall pay all costs for, and furnish to the Owner before final billing, all certificates necessary as evidence that the work installed conforms with all regulations where they apply to this work.

1.19 POST-INSTALLED ANCHORS

- A. Quality Assurance:
 - 1. Use Post-Installed Anchors that have been designed and tested in accordance with:
 - a. NYS: ACI 318, as amended by NYSBC Section 1905.
 - b. Current ICC-ES reports considered evidence of successful testing.
 - 2. Acceptable Manufacturers:
 - a. Hilti, Inc: www.us.hilti.com.
 - b. Simpson Strong-Tie Company, Inc.: www.strongtie.com
 - c. DeWalt Anchors and Fasteners: www.anchors.dewalt.com/anchors.
- B. Provide Post-Installed Anchors as follows:
 - 1. Anchor shall have a current ICC-ES report for the base material.
 - 2. Select and install anchor based on concrete strength indicated by core tests. Otherwise, assume 2,000 psi concrete.
 - 3. Provide AISI 316 Stainless Steel Post-Installed Anchors in corrosive environments.
 - 4. All anchors installed on underside of concrete slab shall be approved for use in cracked concrete.
 - 5. Spacing and edge distance of anchors shall conform to the requirements of the structural engineer or anchor manufacture.
 - 6. Use a safety factor of 4 to the proof tensile load of the anchor when determining the allowable design tensile load.
- C. Installation Requirements:
 - 1. Comply with post-installed anchor manufacturer's recommendations for adhesive storage temperature and conditions for adhesive anchors before, during and after installation.
 - 2. Only store solvent-cured materials in ventilated areas.
 - 3. Follow OSHA requirements when performing any drilling that can result in silica dust.
 - 4. Post-installed adhesive anchors installed overhead shall be installed by persons certified by ACI to perform such installations.
 - 5. All post-installed anchors shall be installed in accordance with manufacturer's installation instructions and current ICC-ES reports.
- D. Inspection of Post-Installed Anchors:
 - 1. Method of inspection shall be at the discretion of the Special Inspector.
 - 2. Contractor shall provide all required information, drawings, equipment documentation, etc. requested by the Special Inspector a minimum of 10 working days in advance of the inspection.

3. Periodic Inspection: Mechanical and screw anchors installed in any orientation are subject to periodic inspection. Frequency of inspections shall be at the Special Inspector's discretion.

1.20 FIRESTOPPING

A. Quality Assurance:

1. Use firestopping systems that have been tested in accordance with ASTM E814 or UL 1479. Listing by UL (DIR), UL (FDR), FM (AG), or ITS (DIR) in their certification directories will be considered evidence of successful testing.
2. Manufacturer Qualifications: Company specializing in manufacturing the products for use in fire rated assemblies with minimum three years documented experience.
 - a. 3M Fire Protection Products: www.3m.com/firestop.
 - b. Hilti, Inc: www.us.hilti.com.
 - c. Specified Technologies Inc: www.stifirestop.com.

B. Firestopping Assembly Requirements

1. For membrane and through penetrations, provide firestopping materials to create a listed system, for the assembly being penetrated and field conditions, that have the following properties, except as otherwise permitted by the Building Code:
 - a. Fire Resistance: Provide systems that have been tested to show F-Rating equal to required fire rating of penetrated assembly.
 - b. Temperature Rise: Provide systems that have been tested to show T-Rating equal to or greater than the F-Rating.
 - c. Air Leakage: Provide systems that have been tested to show L-Rating is equal to or greater than the L-Rating of joints in assembly being penetrated.
 - d. Watertightness: Provide systems that have been tested to meet a Class 1 W-Rating for floor penetrations.

C. Field Conditions

1. Comply with firestopping manufacturer's recommendations for temperature and conditions during and after installation; maintain minimum temperature before, during, and for three days after installation of materials.
2. Provide ventilation in areas where solvent-cured materials are being installed.

D. Inspection of Firestopping Systems

1. Method of inspection shall be at the discretion of the Special Inspector. Contractor shall provide all required information, coordinate with Special Inspector at least 10 days in advance of fire stop installation, and arrange site access. Contractor shall completely remove and restore all firestopping that has undergone destructive testing. No claims for additional cost or time will be allowed.
2. Visual Inspection: Special Inspector shall be onsite during installation and randomly witness a minimum of 10% of each type of fire stop being installed.
3. Destructive Testing: Verification of firestopping after installation has taken place. A minimum of 2%, but not less than one, of each type of fire stop shall be inspected per floor or each area of a floor when a floor area is larger than 10,000 sq. ft.

1.21 OPERATING & MAINTENANCE INSTRUCTION

- A. Prepare operating and maintenance instructions manual including operating instructions, maintenance instructions, manufacturer's data, specific equipment data.

- B. Provide an alphabetical list of all system components, with the name, address, and 24-hour phone number of the company responsible for servicing each item during the first year of operation.
- C. Provide operating instructions for complete system, including:
 - 1. Normal starting, operating, and shut-down
 - 2. Emergency procedures for fire or failure of major equipment
 - 3. Summer and winter special procedures
 - 4. Day and night special procedures
- D. Provide maintenance instructions, including:
 - 1. Valve tag list and equipment tag list
 - 2. Proper lubricants and lubricating instructions for each piece of equipment, and date when lubricated
 - 3. Required cleaning, replacement and/or adjustment schedule
- E. Provide manufacturer's data on each piece of equipment, including:
 - 1. Installation instructions.
 - 2. Drawings and specifications.
 - 3. Parts list, including recommended items to be stocked.
 - 4. Complete wiring and temperature control diagrams.
 - 5. Marked or revised prints locating all concealed parts and all variations from the original system design.
 - 6. Test and inspection certificates.
- F. Provide specific equipment data including, but not limited to, the following:
 - 1. For Plumbing Systems:
 - a. Piping.
 - b. Accessories.
 - c. Electric wiring.
 - 2. For Automatic Control System:
 - a. Drawings and description of system controlled.
 - b. Sequence of operation for each system.
 - c. Data on components.
 - d. Wiring and piping, schematic any layout, for panels and panelboards.
 - e. System operating manual, including set points.
- G. Provide instruction of operating personnel.
 - 1. Instruct Owner's operating personnel in proper starting sequences, operation, shutdown, and maintenance procedures, including normal and emergency procedures.
 - 2. Instruction to be by personnel skilled in operation of equipment. Instructions for major equipment to be by equipment manufacturers' representatives.
 - 3. Make arrangements to give instructions by system and not by building areas.
 - 4. Provide five (5) instruction sessions not to exceed six (6) hours each.
 - 5. Instructions on automatic controls to be by manufacturer's representative.
- H. Submittals
 - 1. Shop Drawings: Submit three copies for review prior to final issuance.
 - 2. Provide six (6) copies of each operation and maintenance manual.
 - a. Manuals to be 8-1/2" x 11 size in hard-back, 3-ring loose leaf binders. Use more than one volume if required. Do not overfill binders.

- b. Manuals to be completed and delivered to the Engineer for approval at least 20 days prior to instruction of operating personnel.
- 3. Prepare separate manuals for the Plumbing system.

1.22 TOOLS FOR OPERATION, ADJUSTMENT AND MAINTENANCE

- A. Deliver to Owner's representative all special tools needed for proper operation, adjustment and maintenance of equipment.

1.23 BASE BID MANUFACTURERS

- A. Base bid materials or equipment are specified by name of manufacturer, brand or trade name and catalog reference.
- B. The choice will be optional with bidder where two or more manufacturers are named.
- C. Manufacturers, other than specified, will only be considered if at the time of bid, manufacturers' names and proposed substitutions are named and stated and the difference in base bid is indicated including changes in the cost of all affected work. Detail equality and difference, item by item, for submission of manufacturers' equipment other than specified.
- D. The following are base bid manufacturers for items under this Section:
 - 1. Access doors: Karp Associates, Inc., Higgins Mfg. Co., Milcor Steel Co., and Walsh-Spencer Co.
 - 2. Inserts: F and S Mfg Co., Fee and Mason and Grinnell.
 - 3. Hangers and supports: I.T.T. Grinnell, Carpenter and Patterson, Inc., and Fee & Mason.
 - 4. Paint: Sherwin-Williams, Benjamin Moore, Pittsburgh Paint Co., Pratt and Lambert, and Rust-Oleum.
 - 5. Gratings: Irving Grating IKG Industries and Ryerson - Inland Steel Co.

1.24 EXPANSION ANCHORS

- A. Provide smooth wall, non-self-drilling internal plug expansion type anchors constructed of AISC 12L14 steel and zinc plated in accordance with Fed. Spec. QQ-A-325 Type 1, Class 3.
- B. Do not exceed 1/4 of average values for a specific anchor size using 2000 psig (13,800 kpa) concrete only, for maximum working load.
- C. Provide spacing and install anchors in accordance with manufacturer's recommendations.

1.25 FOUNDATIONS

- A. Provide concrete foundations for equipment.
 - 1. Mixture:
 - a. One part Portland cement, two parts fine aggregate, and four parts coarse aggregate.
 - b. Concrete shall be the same consistency as specified under General Construction Work.
 - c. Provide concrete, poured in place on roughened concrete floor, cleaned and slushed with coat of cement grout. Do not pour foundation unit concrete has set. Foundation shall be puddled and finished smooth.
 - 2. Hold vibration isolation and anchor bolts in position during pour. Set anchor bolts in oversized sleeves with washers and nuts at bottom. Finish bolts shall be slush with nuts on top. Foundations shall extend 6 in. beyond equipment, except as noted.
 - 3. Provide a minimum of 4 in. concrete foundations. Provide a minimum as required for installation of J bolts for foundations under built up air handling units.
 - 4. Forms: Provide 18-gauge galvanized steel form with welded seams and joints, cross-strip bracing welded to top and bottom angle edges and intermediate bracing welded or riveted

to sides as required. Bend top and bottom edges to form 2-inch integral internal angles (bend back exposed edges).

5. Forms; Provide moisture-resistant commercial standard fir with non-staining mineral oil interior surface coating with rounded or chamfered edges.
 6. Forms: Forms will be provided under General Construction Work.
- B. Coordinate foundations for:
1. Refrigeration equipment.
 2. As noted.

1.26 WATERPROOFING

- A. Where any work pierces waterproofing, installation shall be subject to review, provide all necessary sleeves, caulking, flashing and flashing fittings required to make openings absolutely watertight.
1. Flashing:
 - a. Provide 6 pounds lead.
 - b. Provide 16 ounces lead coated copper.
 - c. Provide No. 22 USSG aluminum.
 - d. Provide galvanized cast iron bottom roof type fittings, similar to Josam No. 26440 or No. 26450 for piping through roof.

1.27 FIELD QUALITY CONTROL

- A. Perform tests as noted, and as required by governing authority having jurisdiction in the presence of Architect and/or Engineer and authorities having jurisdiction.
- B. Provide all required labor, material, equipment, and connections necessary for tests and submit results for review.
- C. Repair or replace defective work and pay for restoring or replacing damaged work due to tests, and retest to the satisfaction of the Architect/Engineer and governing authorities having jurisdiction.
- D. Pay for following required services:
1. Controlled Inspection services as required by the Local Buildings Department.

1.28 CLEANING

- A. Brush and clean work prior to concealing, painting and acceptance. Perform in stages if directed.
- B. Clean and repair painted exposed work, soiled or damaged, to match adjoining work before final acceptance.
- C. Remove debris from inside and outside of material and equipment.

END OF SECTION

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SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Support and attachment components for equipment, piping, and other HVAC/hydronic work.

1.2 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 230548 - Vibration and Seismic Controls for HVAC.

1.3 REFERENCE STANDARDS

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2015.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2009.
- C. ASTM A181/A181M - Standard Specification for Carbon Steel Forgings, for General - Purpose Piping; 2013.
- D. ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2014.
- E. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings; 1999 (Reapproved 2014).
- F. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; 2013.
- G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2015a.
- H. MFMA-4 - Metal Framing Standards Publication; 2004.
- I. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2009.
- J. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
 - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
 - 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
 - 4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
 - 5. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
 - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 033000.

1.5 QUALITY ASSURANCE

- A. Comply with applicable building code.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 SUPPORT AND ATTACHMENT COMPONENTS

- A. General Requirements:
 - 1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of plumbing work.
 - 2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
 - 3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of 1.5. Include consideration for vibration, equipment operation, and shock loads where applicable.
 - 4. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
 - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
 - c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
 - d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
- B. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
- C. Pipe Stanchions: For pipe runs, use stanchions of same type and material where vertical adjustment is required for stationary pipe.
 - 1. Material: Malleable iron, ASTM A47/A47M; or carbon steel, ASTM A36/A36M.
 - 2. Provide coated or plated saddles to isolate steel hangers from dissimilar metal tube or pipe.
- D. Beam Clamps: MSS SP-58 Types 19 through 23, 25 or 27 through 30 based on required load.
 - 1. Material: ASTM A36/A36M carbon steel or ASTM A181/A181M forged steel.
 - 2. Provide clamps with hardened steel cup-point set screws and lock-nuts for anchoring in place.
- E. Pipe Hangers: For a given pipe run, use hangers of the same type and material.
 - 1. Material: Malleable iron, ASTM A47/A47M; or carbon steel, ASTM A36/A36M.
 - 2. Provide coated or plated hangers to isolate steel hangers from dissimilar metal tube or pipe.

- F. Intermediate Pipe Guides: Use pipe clamps with oversize pipe sleeve that provides clearance around pipe.
 - 1. Pipe Diameter 6 inches and Smaller: Provide minimum clearance of 0.16 inch.
- G. Pipe Shields for Insulated Piping:
 - 1. General Construction and Requirements:
 - a. Surface Burning Characteristics: Comply with ASTM E84 or UL 723.
 - b. Shields Material: UV-resistant polypropylene with glass fill.
 - c. Maximum Insulated Pipe Outer Diameter: 12-5/8 inch.
 - d. Minimum Service Temperature: Minus 40 degrees F.
 - e. Maximum Service Temperature: 178 degrees F.
 - f. Pipe shields to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.
- H. Anchors and Fasteners:
 - 1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive support and attachment components.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Provide independent support from building structure. Do not provide support from piping, ductwork, conduit, or other systems.
- C. Unless specifically indicated or approved by Engineer, do not provide support from suspended ceiling support system or ceiling grid.
- D. Unless specifically indicated or approved by Engineer, do not provide support from roof deck.
- E. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- F. Equipment Support and Attachment:
 - 1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
 - 2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
 - 3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
 - 4. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- G. Secure fasteners according to manufacturer's recommended torque settings.
- H. Remove temporary supports.

3.3 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.

- B. Inspect support and attachment components for damage and defects.
- C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- D. Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION

SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Vibration isolation requirements.
- B. Vibration-isolated equipment support bases.
- C. Vibration isolators.

1.2 REFERENCE STANDARDS

- A. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications; 2015.
- B. ICC (IBC) - International Building Code; 2015.
- C. ICC-ES AC156 - Acceptance Criteria for Seismic Certification by Shake-Table Testing of Nonstructural Components; 2010, with Editorial Revision (2015).
- D. MFMA-4 - Metal Framing Standards Publication; 2004.

1.3 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Design Documents: Prepare and submit all information required for plan review and permitting by authorities having jurisdiction, including but not limited to floor plans, details, and calculations.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets for products, including materials, fabrication details, dimensions, and finishes.
 - 1. Vibration Isolators: Include rated load capacities and deflections; include information on color coding or other identification methods for spring element load capacities.
- D. Shop Drawings - Vibration Isolation Systems:
 - 1. Include dimensioned plan views and sections indicating proposed arrangement of vibration isolators; indicate equipment weights and static deflections.
 - 2. Vibration-Isolated Equipment Support Bases: Include base weights, including concrete fill where applicable; indicate equipment mounting provisions.
- E. Product Data: Provide schedule of vibration isolator type with location and load on each.
- F. Shop Drawings: Indicate and locate vibration isolators, with static and dynamic load on each.
- G. Shop Drawings: Indicate inertia bases and locate vibration isolators, with static and dynamic load on each.

1.4 QUALITY ASSURANCE

- A. Comply with applicable building code.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

PART 2 PRODUCTS

2.1 VIBRATION ISOLATION REQUIREMENTS

- A. Design and provide vibration isolation systems to reduce vibration transmission to supporting structure from vibration-producing HVAC equipment and/or HVAC connections to vibration-isolated equipment.
- B. Comply with applicable general recommendations of ASHRAE (HVACA), where not in conflict with other specified requirements:

- C. General Requirements:
 - 1. Select vibration isolators to provide required static deflection.
 - 2. Select vibration isolators for uniform deflection based on distributed operating weight of actual installed equipment.
- D. Equipment Isolation:
 - 1. Equipment Type: ACCU-1.
 - a. Isolator Type (Seismic Application): Seismic type restrained spring isolators.
- E. Piping Isolation:
 - 1. Provide vibration isolators for piping supports:
 - a. Located within 50 feet of connected vibration-isolated equipment.
 - 2. Minimum Static Deflection:
 - a. First Three Supports Closest to Isolated Equipment: Same as static deflection of equipment; maximum of 2 inch deflection required.
 - b. Remainder of Supports: 0.75 inch deflection unless otherwise indicated.
 - 3. Suspended Piping, Nonseismic Applications: Use resilient material isolator hangers, spring isolator hangers, or combination resilient material/spring isolator hangers.
 - 4. Use modular seal or approved resilient material where vibration-isolated piping penetrates building elements (e.g., walls, floors) arranged to prevent vibration transmission to structure.

2.2 VIBRATION-ISOLATED EQUIPMENT SUPPORT BASES

- A. Manufacturers:
- B. Vibration-Isolated Concrete Inertia Bases:
 - 1. Description: Concrete-filled engineered steel forms with integral mounting provisions for vibration isolators, sized and configured for mounting of equipment.
 - 2. Minimum Base Depth: 4 inches.
 - 3. Minimum Base Mass (Including Concrete): 1.5 times weight of supported equipment.
 - 4. Concrete Reinforcement: Welded or tied reinforcing bars running both ways in a single layer.
 - 5. Concrete: Filled on site with minimum 3000 psi concrete in accordance with Section 033000.

2.3 VIBRATION ISOLATORS

- A. Manufacturers:
 - 1. Vibration Isolators:
 - a. Kinetics Noise Control, Inc: www.kineticsnoise.com/#sle.
 - b. Mason Industries: www.mason-ind.com/#sle.
 - c. Vibration Eliminator Company, Inc: www.veco-nyc.com/#sle.
- B. General Requirements:
 - 1. Resilient Materials for Vibration Isolators: Oil, ozone, and oxidant resistant.
 - 2. Spring Elements for Spring Isolators:
 - a. Color code or otherwise identify springs to indicate load capacity.
 - b. Lateral Stability: Minimum lateral stiffness to vertical stiffness ratio of 0.8.
 - c. Designed to operate in the linear portion of their load versus deflection curve over deflection range of not less than 50 percent above specified deflection.
 - d. Designed to provide additional travel to solid of not less than 50 percent of rated deflection at rated load.

- e. Selected to provide designed deflection of not less than 75 percent of specified deflection.
 - f. Selected to function without undue stress or overloading.
- C. Vibration Isolators for Nonseismic Applications:
 - 1. Resilient Material Isolator Pads:
 - a. Description: Single or multiple layer pads utilizing elastomeric (e.g., neoprene, rubber) or fiberglass isolator material.
 - b. Pad Thickness: As required for specified minimum static deflection; minimum 0.25 inch thickness.
 - c. Multiple Layer Pads: Provide bonded, galvanized sheet metal separation plate between each layer.
 - 2. Resilient Material Isolator Mounts, Nonseismic:
 - a. Description: Mounting assemblies for bolting equipment to supporting structure utilizing elastomeric (e.g., neoprene, rubber) or fiberglass isolator material; fail-safe type.
 - 3. Housed Spring Isolators:
 - a. Description: Isolator assembly consisting of single or multiple free-standing, laterally stable steel spring(s) within a metal housing.
 - b. Furnished with integral elastomeric snubbing elements, nonadjustable type, for limiting equipment movement and preventing metal-to-metal contact between housing elements.
 - c. Bottom Load Plate: Steel with nonskid, elastomeric isolator pad with provisions for bolting to supporting structure as required.
 - d. Furnished with integral leveling device for positioning and securing supported equipment.
 - 4. Spring Isolator Hangers, Nonseismic:
 - a. Description: Isolator assembly designed for installation in hanger rod suspension system utilizing single or multiple free-standing, laterally stable steel spring(s) in series with an elastomeric element for the lower hanger rod connection.
 - b. Designed to accommodate misalignment of bottom hanger rod up to 30 degrees (plus/minus 15 degrees) without short-circuiting of isolation.

2.4 VIBRATION ISOLATORS

- A. Open Spring Isolators:
 - 1. For Exterior and Humid Areas: Hot dipped galvanized housings and neoprene coated springs.
- B. Spring Hangers:
 - 1. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection. Color code springs for load carrying capacity.
 - 2. For Exterior and Humid Areas: Hot dipped galvanized housings and neoprene coated springs.
- C. Neoprene Pad Isolators:
 - 1. Hardness: 30 durometer.
 - 2. Thickness: Minimum 1/2 inch.
 - 3. Maximum Loading: 50 psi.
 - 4. Rib Height: Maximum 0.7 times width.

- 5. Configuration: Single layer.
- 6. Configuration: 1/2 inch thick waffle pads bonded each side of 1/4 inch thick steel plate.
- D. Rubber Mount or Hanger: Molded rubber designed for 0.4 inch deflection with threaded insert.
- E. Glass Fiber Pads: Neoprene jacketed pre-compressed molded glass fiber.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that mounting surfaces are ready to receive vibration isolation and/or seismic control components and associated attachments.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- C. Secure fasteners according to manufacturer's recommended torque settings.
- D. Install flexible piping connections to provide sufficient slack for vibration isolation and/or seismic relative displacements as indicated or as required.
- E. Vibration Isolation Systems:
 - 1. Vibration-Isolated Equipment Support Bases:
 - a. Provide specified minimum clearance beneath base.
 - 2. Spring Isolators:
 - a. Position equipment at operating height; provide temporary blocking as required.
 - b. Lift equipment free of isolators prior to lateral repositioning to avoid damage to isolators.
 - c. Level equipment by adjusting isolators gradually in sequence to raise equipment uniformly such that excessive weight or stress is not placed on any single isolator.
 - 3. Isolator Hangers:
 - a. Use precompressed isolator hangers where required to facilitate installation and prevent damage to equipment utility connection provisions.
 - b. Locate isolator hangers at top of hanger rods in accordance with manufacturer's instructions.
 - 4. Clean debris from beneath vibration-isolated equipment that could cause short-circuiting of isolation.
 - 5. Use elastomeric grommets for attachments where required to prevent short-circuiting of isolation.
 - 6. Adjust isolators to be free of isolation short circuits during normal operation.
 - 7. Do not overtighten fasteners such that resilient material isolator pads are compressed beyond manufacturer's maximum recommended deflection.

3.3 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect vibration isolation and/or seismic control components for damage and defects.
- C. Vibration Isolation Systems:

1. Verify isolator static deflections.
 2. Verify vibration isolation performance during normal operation; investigate sources of isolation short circuits.
- D. Correct deficiencies and replace damaged or defective vibration isolation and/or seismic control components.

END OF SECTION

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SECTION 230993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. This section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other sections.
- B. Sequence of operation for:
 - 1. Refrigeration systems.

1.2 RELATED REQUIREMENTS

- A. Section 230913 - Instrumentation and Control Devices for HVAC.
- B. Section 262816.13 - Enclosed Circuit Breakers.

1.3 SUBMITTALS

- A. Sequence of Operation Documentation: Submit written sequence of operation for entire HVAC system and each piece of equipment.
 - 1. State each sequence in small segments and give each segment a unique number for referencing in Functional Test procedures; provide a complete description regardless of the completeness and clarity of the sequences specified in Contract Documents.
 - 2. Include at least the following sequences:
 - a. Start-up.
 - b. Warm-up mode.
 - c. Normal operating mode.
 - d. Unoccupied mode.
 - e. Shutdown.
 - f. Capacity control sequences and equipment staging.
 - g. Temperature and pressure control, such as setbacks, setups, resets, etc.
 - h. Detailed sequences for all control strategies, such as economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
 - i. Effects of power or equipment failure with all standby component functions.
 - j. Sequences for all alarms and emergency shut downs.
 - k. Seasonal operational differences and recommendations.
 - l. Interactions and interlocks with other systems.
 - 3. Include initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
 - 4. For packaged controlled equipment, include manufacturer's furnished sequence of operation amplified as required to describe the relationship between the packaged controls and the control system, indicating which points are adjustable control points and which points are only monitored.
 - 5. Include schedules, if known.
- B. Control System Diagrams: Submit graphic schematic of the control system showing each control component and each component controlled, monitored, or enabled.
 - 1. Label with settings, adjustable range of control and limits.
 - 2. Include flow diagrams for each control system, graphically depicting control logic.

3. Include the system and component layout of all equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
 4. Include a key to all abbreviations.
 - C. Points List: Submit list of all control points indicating at least the following for each point.
 1. Name of controlled system.
 2. Point abbreviation.
 3. Point description; such as dry bulb temperature, airflow, etc.
 4. Display unit.
 5. Control point or setpoint (Yes / No); i.e. a point that controls equipment and can have its setpoint changed.
 6. Monitoring point (Yes / No); i.e. a point that does not control or contribute to the control of equipment but is used for operation, maintenance, or performance verification.
 - D. Designer's Qualification Statement.
 - E. Project Record Documents: Record actual locations of components and setpoints of controls, including changes to sequences made after submission of shop drawings.
- 1.4 QUALITY ASSURANCE
- A. Design system under direct supervision of a Professional Engineer experienced in design of this Work and licensed in the State in which the Project is located.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 REFRIGERATION SYSTEMS

- A. Maintain constant supply air duct temperature of 55 degrees F by cycling refrigeration system and signalling step capacity, minimum of 2 steps.

END OF SECTION

SECTION 232300 - REFRIGERANT PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Piping.
- B. Refrigerant.
- C. Flexible connections.
- D. Exterior penetration accessories.

1.2 RELATED REQUIREMENTS

- A. Section 078400 - Firestopping.
- B. Section 230719 - HVAC Piping Insulation.
- C. Section 23 8129 - Variable Refrigerant Volume Systems.
- D. Section 230993 - Sequence of Operations for HVAC Controls.
- E. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections.

1.3 REFERENCE STANDARDS

- A. AHRI 495 - Performance Rating of Refrigerant Liquid Receivers; 2005.
- B. AHRI 750 - Standard for Thermostatic Refrigerant Expansion Valves; 2007.
- C. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2013.
- D. ASHRAE Std 34 - Designation and Safety Classification of Refrigerants; 2013.
- E. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes; 2013.
- F. ASME B31.5 - Refrigeration Piping and Heat Transfer Components; 2013.
- G. ASME B31.9 - Building Services Piping; 2014.
- H. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service; 2013.
- I. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers; 1992 (Reapproved 2008).
- J. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding; 2011-AMD 1.
- K. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2009.
- L. MSS SP-69 - Pipe Hangers and Supports - Selection and Application; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.; 2003.
- M. MSS SP-89 - Pipe Hangers and Supports - Fabrication and Installation Practices; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.; 2003.
- N. UL 429 - Electrically Operated Valves; Current Edition, Including All Revisions.

1.4 SYSTEM DESCRIPTION

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

- B. Provide pipe hangers and supports in accordance with ASME B31.5 and MSS SP-69 unless indicated otherwise.
- C. Flexible Connectors: Utilize at or near compressors where piping configuration does not absorb vibration.

1.5 SUBMITTALS

- A. Product Data: Provide general assembly of specialties, including manufacturers catalogue information. Provide manufacturers catalog data including load capacity.
- B. Shop Drawings: Indicate schematic layout of system, including equipment, critical dimensions, and sizes.
- C. Submit 3/8" scaled piping shop drawings indicating pipe materials, routing, sizes, elevations, transistions, ceiling plan, structure, etc. Provide scaled elevations and sections for equipment rooms and as directed by the Engineer.
- D. Design Data: Submit design data indicating pipe sizing. Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.
- E. Test Reports: Indicate results of leak test, acid test.
- F. Manufacturer's Installation Instructions: Indicate support, connection requirements, and isolation for servicing.
- G. Installer's qualification statement.
- H. Project Record Documents: Record exact locations of equipment and refrigeration accessories on record drawings.
- I. Maintenance Data: Include instructions for changing cartridges, assembly views, spare parts lists.

1.6 QUALITY ASSURANCE

- A. Designer Qualifications: Design piping system under direct supervision of a Professional Engineer experienced in design of this type of work and licensed in the State in which the Project is located.
- B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum 5 years of documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store piping and specialties in shipping containers with labeling in place.
- B. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.
- C. Dehydrate and charge components such as piping and receivers, seal prior to shipment, until connected into system.

PART 2 PRODUCTS

2.1 PIPING

- A. Copper Tube: ASTM B280, H58 hard drawn or O60 soft annealed.
 - 1. Fittings: ASME B16.22 wrought copper.
 - 2. Joints: Braze, AWS A5.8M/A5.8 BCuP silver/phosphorus/copper alloy.
- B. Copper Tube to 7/8 inch OD: ASTM B88 (ASTM B88M), Type K (A), annealed.
 - 1. Fittings: ASME B16.26 cast copper.

2. Joints: Flared.

C. Pipe Supports and Anchors:

1. Conform to ASME B31.5, ASTM F 708, MSS SP-58, MSS SP-69, and MSS SP-89.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Carbon steel split ring adjustable swivel, split ring.
3. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
4. Vertical Support: Steel riser clamp.
5. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
6. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

2.2 REFRIGERANT

- A. Refrigerant: R410A as defined in ASHRAE Std 34.

PART 3 EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

- A. Install refrigeration specialties in accordance with manufacturer's instructions.
- B. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.
- C. Install piping to conserve building space and avoid interference with use of space.
- D. Group piping whenever practical at common elevations and locations. Slope piping one percent in direction of oil return.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- F. Pipe Hangers and Supports:
1. Install in accordance with ASME B31.5.
 2. Support horizontal piping as indicated.
 3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
 4. Place hangers within 12 inches of each horizontal elbow.
 5. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 7. Provide copper plated hangers and supports for copper piping.
- G. Arrange piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required. Slope horizontal piping 0.40 percent in direction of flow.
- H. Provide clearance for installation of insulation and access to valves and fittings.
- I. Provide access to concealed valves and fittings. Coordinate size and location of access doors with Section 083100.
- J. Flood piping system with nitrogen when brazing.

- K. Where pipe support members are welded to structural building frame, brush clean, and apply one coat of zinc rich primer to welding.
- L. Prepare unfinished pipe, fittings, supports, and accessories ready for finish painting. See Section 099123.
- M. Follow ASHRAE Std 15 procedures for charging and purging of systems and for disposal of refrigerant.
- N. Install flexible connectors at right angles to axial movement of compressor, parallel to crankshaft.
- O. Fully charge completed system with refrigerant after testing.

3.3 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Test refrigeration system in accordance with ASME B31.5.
- C. Pressure test system with dry nitrogen to 200 psi. Perform final tests at 27 inches vacuum and 200 psi using electronic leak detector. Test to no leakage.

3.4 SCHEDULES

- A. Hanger Spacing for Copper Tubing.
 - 1. 1/2 inch, 5/8 inch, and 7/8 inch OD: Maximum span, 5 feet; minimum rod size, 1/4 inch.
 - 2. 1-1/8 inch OD: Maximum span, 6 feet; minimum rod size, 1/4 inch.
 - 3. 1-3/8 inch OD: Maximum span, 7 feet; minimum rod size, 3/8 inch.

END OF SECTION

SECTION 238129 - VARIABLE REFRIGERANT FLOW HVAC SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Variable refrigerant volume HVAC system includes:
 - 1. Outdoor/condensing unit(s).
 - 2. Indoor/evaporator units.
 - 3. Refrigerant piping.
 - 4. Control wiring.

1.2 RELATED REQUIREMENTS

- A. Section 232300 - Refrigerant Piping: Additional requirements for refrigerant piping system.
- B. Section 260583 - Wiring Connections: Power connections to equipment.

1.3 PRICE AND PAYMENT PROCEDURES

- A. Alternates: Owner requests a bid Alternate for a system designed and manufactured by a manufacturer other than that listed as the Basis of Design.
 - 1. Alternate systems will be considered only under the terms described for Substitutions in the article MANUFACTURERS in PART 2 of this section.
 - 2. Contractor shall include with Contractor's bid the amount to be deducted from the bid amount if the alternate is accepted by the Owner.

1.4 REFERENCE STANDARDS

- A. AHRI 210/240 - Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment; 2008.
- B. ASCE 7 - Minimum Design Loads for Buildings and Other Structures; 2010, with 2013 Supplements and Errata.
- C. ASHRAE (FUND) - ASHRAE Handbook - Fundamentals; 2013.
- D. ASHRAE Std 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings; 2013, Including All Addenda.
- E. ITS (DIR) - Directory of Listed Products; current edition.
- F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- G. UL 1995 - Heating and Cooling Equipment; Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

1.6 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Pre-Bid Submittals: For proposed substitute systems/products, as defined in PART 2, and alternate systems/products, as defined above, proposer shall submit all data described in this article, under the terms given for substitutions stated in PART 2.
- C. Product Data: Submit manufacturer's standard data sheets showing the following for each item of equipment, marked to correlate to equipment item markings indicated in Contract Documents:
 - 1. Outdoor/Central Units:

- a. Refrigerant Type and Size of Charge.
 - b. Cooling Capacity: Btu/h.
 - c. Heating Capacity: Btu/h.
 - d. Cooling Input Power: Btu/h.
 - e. Heating Input Power: Btu/h.
 - f. Operating Temperature Range, Cooling and Heating.
 - g. Air Flow: Cubic feet per minute.
 - h. Fan Curves.
 - i. External Static Pressure (ESP): Inches WG.
 - j. Sound Pressure Level: dB(A).
 - k. Electrical Data:
 - 1) Maximum Circuit Amps (MCA).
 - 2) Maximum Fuse Amps (MFA).
 - 3) Maximum Starting Current (MSC).
 - 4) Full Load Amps (FLA).
 - 5) Total Over Current Amps (TOCA).
 - 6) Fan Motor: HP.
 - l. Weight and Dimensions.
 - m. Maximum number of indoor units that can be served.
 - n. Maximum refrigerant piping run from outdoor/condenser unit to indoor/evaporator unit.
 - o. Maximum height difference between outdoor/condenser unit to indoor/evaporator unit, both above and below.
 - p. Control Options.
 - 2. Indoor/Evaporator Units:
 - a. Cooling Capacity: Btu/h.
 - b. Heating Capacity: Btu/h.
 - c. Cooling Input Power: Btu/h.
 - d. Heating Input Power: Btu/h.
 - e. Air Flow: Cubic feet per minute.
 - f. Fan Curves.
 - g. External Static Pressure (ESP): Inches WG.
 - h. Sound Pressure level: dB(A).
 - i. Electrical Data:
 - 1) Maximum Circuit Amps (MCA).
 - 2) Maximum Fuse Amps (MFA).
 - 3) Maximum Starting Current (MSC).
 - 4) Full Load Amps (FLA).
 - 5) Total Over Current Amps (TOCA).
 - 6) Fan Motor: HP.
 - j. Maximum Lift of Built-in Condensate Pump.
 - k. Weight and Dimensions.
 - l. Control Options.
 - 3. Control Panels: Complete description of options, control points, zones/groups.
- D. Operating and Maintenance Data:
- 1. Manufacturer's complete standard instructions for each unit of equipment and control panel.

2. Custom-prepared system operation, troubleshooting, and maintenance instructions and recommendations.
 3. Identification of replaceable parts and local source of supply.
- E. Project Record Documents: Record the following:
1. As-installed routing of refrigerant piping and condensate piping.
 2. Locations of access panels.
 3. Locations of control panels.

1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
1. Company that has been manufacturing variable refrigerant volume heat pump equipment for at least 5 years.
 2. Company that provides system design software to installers.
- B. Installer Qualifications: Trained and approved by manufacturer of equipment.

1.8 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, and handle equipment and refrigerant piping according to manufacturer's recommendations.

1.9 WARRANTY

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Compressors: Provide manufacturer's warranty for six (6) years from date of installation. During the stated period, should any part fail due to defects in material and workmanship, it shall be repaired or replaced at the discretion of Daikin AC (Americas), Inc. according to Daikin's terms and conditions. All warranty service work shall be preformed by a Daikin factory trained service professional.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Basis of Design: The system design indicated in Contract Documents is based on equipment and system designed by Daikin AC; www.daikinac.com/#sle.

2.2 HVAC SYSTEM DESIGN

- A. System Operation: Heating or cooling, selected at system level.
1. Zoning: Provide capability for temperature control for each individual indoor/evaporator unit independently of all other units.
 2. Zoning: Provide heating/cooling selection for each individual indoor/evaporator unit independently of all other units.
 - a. Exception: Where indicated, multiple indoor/evaporator units may be controlled in groups.
 3. Provide a complete functional system that achieves the specified performance based on the specified design conditions and that is designed and constructed according to the equipment manufacturer's requirements.
 4. Conditioned spaces are indicated on drawings.
 5. Outdoor/Condenser unit locations are indicated on drawings.
 6. Indoor/Evaporator unit locations are indicated on drawings.
 7. Required equipment unit capacities are indicated on drawings.
 8. Refrigerant piping sizes are not indicated on drawings.

9. Connect equipment to condensate piping provided by others; condensate piping is indicated on drawings.
- B. Cooling Mode Interior Performance:
 1. Daytime Setpoint: 75 degrees F, plus or minus 2 degrees F.
 2. Setpoint Range: 72 degrees F to 76 degrees F.
 3. Night Setback: 85 degrees F.
 4. Interior Relative Humidity: 50 percent, maximum.
- C. Heating Mode Interior Performance:
 1. Daytime Setpoint: 70 degrees F, plus or minus 2 degrees F.
 2. Setpoint Range: 65 degrees F to 75 degrees F.
 3. Night Setback: 60 degrees F.
- D. Outside Air Design Conditions:
 1. Summer Outside Air Design Temperature: 89 degrees F dry-bulb; 76 degrees F wet-bulb.
 2. Winter Outside Air Design Temperature: 15 degrees F dry-bulb.
- E. Energy Design Wind Speed: 25 mph.
- F. Operating Temperature Ranges:
 1. Cooling Mode Operating Range: 23 degrees F to 110 degrees F dry bulb.
 2. Heating Mode Operating Range: 15 degrees F to 110 degrees F dry bulb; minus 4 degrees F to 60 degrees F wet bulb; without low ambient controls or auxiliary heat source.
- G. Refrigerant Piping Lengths: Provide equipment capable of serving system with following piping lengths without any oil traps:
 1. Minimum Piping Length from Outdoor/Central Unit(s) to Furthest Terminal Unit: 230 feet, actual; 296 feet, equivalent.
 2. Total Combined Liquid Line Length: 985 feet, minimum.
 3. Maximum Vertical Distance Between Outdoor/Central Unit(s) and Terminal Units: 98 feet.
- H. Controls: Provide the following control interfaces:
 1. Remote, multizone on/off control panels sufficient to control all units; locate where indicated.

2.3 EQUIPMENT

- A. All Units: Factory assembled, wired, and piped and factory tested for function and safety.
 1. Refrigerant: R-410A.
 2. Performance Certification: AHRI Certified; www.ahrinet.org.
 3. Safety Certification: Tested to UL 1995 by UL or Intertek-ETL, listed in ITS (DIR), and bearing the certification label.
 4. Provide outdoor/condensing units capable of serving indoor unit capacity up to 200 percent of the capacity of the outdoor/condensing unit.
 5. Provide units capable of serving the zones indicated.
 6. Thermal Performance: Provide heating and cooling capacity as indicated, based on the following nominal operating conditions:
 - a. Cooling: Indoor air temperature of 80 degrees F dry bulb, 67 degrees F wet bulb; outdoor air temperature of 95 degrees F dry bulb; and 25 feet
 - b. Heating: Outdoor air temperature of 15 degrees F dry bulb, 110 degrees F wet bulb; indoor air temperature of 70 degrees F dry bulb; and 25 feet

7. Energy Efficiency: Report EER and COP based on tests conducted at “full load” in accordance with AHRI 210/240 or alternate test method approved by U.S. Department of Energy.
 8. Outdoor Units: Units and their supports designed and installed to resist wind pressures defined in ASCE 7.
- B. Electrical Characteristics:
1. Power - Condensing Units: 208 to 230 Volts, 3-phase, 60 Hz.
 2. Power - Indoor Units: 208 to 230 Volts, single phase, 60 Hz.
 3. 208-230 Voltage Range: 187 to 253 volts.
- C. System Controls:
1. Include self diagnostic, auto-check functions to detect malfunctions and display the type and location.
- D. Remote Centralized Control Panel:
- E. Unit Controls: As required to perform input functions necessary to operate system; provided by manufacturer of units.
1. Provide interfaces to remote control and building automation systems as specified.
 2. Outside air capability.
- F. Wiring:
1. Control Wiring: 18 AWG, 2-conductor, non-shielded, non-polarized, stranded cable.
 2. Control Wiring Configuration: Daisy chain.
- G. Refrigerant Piping:
1. Provide three-pipe refrigerant system, including high/low pressure dedicated hot gas, liquid and suction lines; two-pipe systems utilizing lower temperature mixed liquid/gas refrigerant to perform heat recovery are not permitted due to reduced heating capabilities.
 2. Refrigerant Flow Balancing: Provide refrigerant piping joints and headers specifically designed to ensure proper refrigerant balance and flow for optimum system capacity and performance; T-style joints are prohibited.
 3. Insulate each refrigerant line individually between the condensing and indoor units.

2.4 OUTDOOR/CONDENSING UNITS

- A. Outdoor/Condensing Units: Air-cooled DX refrigeration units, designed specifically for use with indoor/evaporator units; factory assembled and wired with all necessary electronic and refrigerant controls; modular design for ganging multiple units.
1. Refrigeration Circuit: Scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports and refrigerant regulator.
 2. Refrigerant: Factory charged.
 3. Variable Volume Control: Modulate compressor capacity automatically to maintain constant suction and condensing pressures while varying refrigerant volume to suit heating/cooling loads.
 4. Capable of being installed with wiring and piping to the left, right, rear or bottom.
 5. Capable of heating operation at low end of operating range as specified, without additional low ambient controls or auxiliary heat source; during heating operation, reverse cycle (cooling mode) oil return or defrost is not permitted, due to potential reduction in space temperature.

6. Sound Pressure Level: As specified, measured at 3 feet from front of unit; provide night setback sound control as a standard feature; three selectable sound level steps of 55 dB, 50 dB, and 45 dB, maximum.
7. Power Failure Mode: Automatically restart operation after power failure without loss of programmed settings.
8. Provide refrigerant auto-charging feature and refrigerant charge check function.
9. Provide refrigerant auto-charging feature.
10. Safety Devices: High pressure sensor and switch, low pressure sensor/switch, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
11. Provide refrigerant sub-cooling to ensure the liquid refrigerant does not flash when supplying to indoor units.
12. Oil Recovery Cycle: Automatic, occurring 2 hours after start of operation and then every 8 hours of operation; maintain continuous heating during oil return operation.
13. Controls: Provide contacts for electrical demand shedding.
14. Product:
 - a. Daikin RXYQ Series ("heat pump").
- B. Unit Cabinet: Weatherproof and corrosion resistant; rust-proofed mild steel panels coated with baked enamel finish.
 1. Designed to allow side-by-side installation with minimum spacing.
- C. Fans: One or more direct-drive propeller type, vertical discharge, with multiple speed operation via DC (digitally commutating) inverter.
 1. Provide minimum of 2 fans for each condensing unit.
 2. External Static Pressure: Factory set at 0.12 in WG, minimum.
 3. Indoor Mounted Air-Cooled Units: External static pressure field set at 0.32 in WG, minimum; provide for mounting of field-installed ducts.
 4. Fan Airflow: As indicated for specific equipment.
 5. Fan Motors: Factory installed; permanently lubricated bearings; inherent protection; fan guard; output as indicated for specific equipment.
- D. Condenser Coils: Copper tubes expanded into aluminum fins to form mechanical bond; waffle louver fin and rifled bore tube design to ensure high efficiency performance.
 1. Copper Tube: Hi-X seamless copper tube.
 2. Coil Design: N-shape internal grooves mechanically bonded on to aluminum fins to an e-Pass Design.
 3. Corrosion Protection: Fins coated with anti-corrosion acrylic resin and hydrophilic film type E1; pipe plates coated with powdered polyester powder coating of 2.0 to 3.0 microns thickness.
- E. Compressors: Scroll type, hermetically sealed, variable speed inverter-driven and fixed speed in combination to suit total capacity; minimum of one variable speed, inverter driven compressor per condenser unit; minimum of two compressors per condenser unit; capable of controlling capacity within range of 6 percent to 100 percent of total capacity.
 1. Variable Speed Control: Capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure; high/low pressures calculated by samplings of evaporator and condenser temperatures every 20 seconds, with compressor capacity adjusted to eliminate deviation from target value by changing inverter frequency or on/off setting of fixed speed compressors.

2. Multiple Condenser Modules: Balance total operation hours of compressors by means of duty cycling function, providing for sequential starting of each module at each start/stop cycle, completion of oil return, and completion of defrost, or every 8 hours.
3. Failure Mode: In the event of compressor failure, operate remaining compressor(s) at proportionally reduced capacity; provide microprocessor and associated controls specifically designed to address this condition.
4. Inverter Driven Compressors: PVM inverter driven, highly efficient reluctance DC (digitally commutating), hermetically sealed scroll "G2-type" with maximum speed of 7,980 rpm.
5. Rotors: Incorporating neodymium magnets for higher torque and efficiency; at complete stop of compressor, position rotor into optimum position for low torque start.
6. Provide each compressor with crankcase heater, high pressure safety switch, and internal thermal overload protector.
7. Provide oil separators and intelligent oil management system.
8. Provide spring mounted vibration isolators.

2.5 INDOOR/EVAPORATOR UNITS

- A. All Indoor/Evaporator Units: Factory assembled and tested DX fan-coil units, with electronic proportional expansion valve, control circuit board, factory wiring and piping, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
 1. Refrigerant: Refrigerant circuits factory-charged with dehydrated air, for field charging.
 2. Temperature Control Mechanism: Return air thermistor and computerized Proportional-Integral-Derivative (PID) control of superheat.
 3. Dehumidification Function: In conjunction with wall-mounted wired remote controller.
 4. Coils: Direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond; waffle louver fin and high heat exchange, rifled bore tube design; factory tested.
 - a. 2-, 3-, or 4-row cross fin design with 14 to 17 fins per inch.
 - b. Flare connections to refrigerant piping.
 - c. Provide thermistor on liquid and gas lines.
 5. Fans: Direct-drive, with statically and dynamically balanced impellers; high and low speeds unless otherwise indicated; motor thermally protected.
 6. Return Air Filter: Washable long-life net filter with mildew proof resin, unless otherwise indicated.
 - a. Where high efficiency filters are indicated, provide air filter rack.
 7. Condensate Drainage: Built-in condensate drain pan with PVC drain connection.
 - a. Units With Built-In Condensate Pumps: Provide condensate safety shutoff and alarm.
 - b. Units Without Built-In Condensate Pump: Provide built-in condensate float switch and wiring connections.
 8. Cabinet Insulation: Sound absorbing foamed polystyrene and polyethylene insulation.
- B. Recessed Ceiling Units - 2 FT by 2 FT: Four-way airflow cassette with central return air grille, sized for installation in standard 24 by 24 inch lay-in ceiling grid.
 1. Cabinet Height: Maximum of 12 inches above face of ceiling.
 2. Exposed Housing: White, impact resistant, with washable decoration panel.
 3. Maintenance Access: All electrical components accessible through decoration panel.
 4. Supply Airflow Adjustment:

- a. Via motorized louvers which can be horizontally and vertically adjusted from 0 to 90 degrees.
 - b. Field-modifiable to 3-way and 2-way airflow.
 - c. Three auto-swing positions, including standard, draft prevention and ceiling stain prevention.
5. Sound Pressure: Measured at low speed at 5 feet below unit.
 6. Fan: Direct-drive turbo type.
 7. Condensate Pump: Built-in, with lift of 21 inches, minimum.
 8. Provide side-mounted supply air branch duct connection.
 9. Provide side-mounted fresh air intake duct connection.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that required electrical services have been installed and are in the proper locations prior to starting installation.
- B. Verify that condensate piping has been installed and is in the proper location prior to starting installation.
- C. Notify Engineer if conditions for installation are unsatisfactory.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install refrigerant piping in accordance with equipment manufacturer's instructions.
- C. Perform wiring in accordance with NFPA 70, National Electric Code (NEC).
- D. Coordinate with installers of systems and equipment connecting to this system.

3.3 FIELD QUALITY CONTROL

3.4 SYSTEM STARTUP

- A. Provide manufacturer's field representative to perform system startup.
- B. Prepare and start equipment and system in accordance with manufacturer's instructions and recommendations.
- C. Adjust equipment for proper operation within manufacturer's published tolerances.

3.5 CLEANING

- A. Clean exposed components of dirt, finger marks, and other disfigurements.

3.6 CLOSEOUT ACTIVITIES

- A. See Section 017800 - Closeout Submittals, for closeout submittals.
- B. See Section 017900 - Demonstration and Training, for additional requirements.
- C. Demonstrate proper operation of equipment to Owner's designated representative.
- D. Demonstration: Demonstrate operation of system to Owner's personnel.
 1. Use operation and maintenance data as reference during demonstration.
 2. Conduct walking tour of project.
 3. Briefly describe function, operation, and maintenance of each component.
- E. Training: Train Owner's personnel on operation and maintenance of system.
 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.

2. Provide minimum of one day of training.
3. Instructor: Manufacturer's training personnel.
4. Location: At project site.

3.7 PROTECTION

- A. Protect installed components from subsequent construction operations.
- B. Replace exposed components broken or otherwise damaged beyond repair.

END OF SECTION