

**DIVISION 23****HEATING, VENTILATION AND AIR-CONDITIONING (HVAC)**

23 00 00	Heating, Ventilating and Air Conditioning (HVAC) Basic Requirements
23 05 13	Common Motor Requirements for HVAC Equipment
23 05 29	Hangers and Supports for HVAC Piping, Ductwork and Equipment
23 05 48	Vibration and Seismic Controls for HVAC Equipment
23 05 53	Identification for HVAC Piping, Ductwork and Equipment
23 05 93	Testing, Adjusting, and Balancing for HVAC
23 07 00	HVAC Insulation
23 21 13	HVAC Piping
23 31 00	HVAC Ducts and Casings
23 33 00	Air Duct Accessories
23 37 00	Air Outlets and Inlets
23 81 26	Small Split System and Unitary HVAC Equipment



**SECTION 23 00 00****HEATING, VENTILATING AND AIR CONDITIONING (HVAC) BASIC REQUIREMENTS****PART 1 - GENERAL****1.01 DESIGN-BUILD SUMMARY OF WORK**

- A. Work included in 23 00 00 applies to Division 23, Heating, Ventilating and Air Conditioning (HVAC) work to provide materials, labor, tools, permits and incidentals to make HVAC systems ready for Owner's use for proposed project.

**1.02 DESIGN-BUILD INSTRUCTIONS**

- A. This document is issued to give Bidders a basis for preparing a proposal to design and install complete HVAC systems for this project.
- B. Alternates to this Document may be offered as a separate proposal.
- C. Bidder to submit the following information with the Proposal:
  - 1. Preliminary drawings indicating major equipment locations and preliminary layout.
  - 2. Description of systems, manufacturer and method of control.
  - 3. List of materials proposed for systems which are applicable to this project.
  - 4. Any other information which the bidder considers pertinent in evaluating the proposal.

**1.03 DESIGN-BUILD DESIGN APPROACH**

- A. Use this Specification as a guide for design/engineering requirements, workmanship and materials or construction. Utilize design-build concept throughout construction phase of project.
- B. Investigate and be apprised of applicable codes, rules, and regulations as enforced by Authority Having Jurisdiction (AHJ).
- C. Visit the Site of the proposed construction. Verify and inspect the existing site to determine conditions that affect this work.

**1.04 DESIGN-BUILD DESIGN CRITERIA/CALCULATIONS**

- A. Related Work Specified Elsewhere:
  - 1. Contents of Section apply to Division 23 Specifications.
  - 2. Requirements of Section are a minimum for Division 23 Sections, unless otherwise stated in each Section, in which case that Section's requirements take precedence.
- B. Design Criteria:
  - 1. HVAC System: In addition to making the existing system (air handling units, boilers, heating water pumps, & finned tube radiators) operational again, provide cooling by adding standalone mini split systems (LG, Mitsubishi, Daikin, or equal) to classrooms, commons areas, and office/admin areas. Provide wall mounted indoor fan coil units with integral condensate pumps and drains routed to nearby sink tail pieces, and mount outdoor condensing units on exterior walls using angle iron frames with neoprene isolators. Provide standalone, programmable thermostats for each zone. For the new classroom restrooms, provide an inline exhaust fan at each group of restrooms with ceiling mounted exhaust grilles ducted to a roof mounted hood. In the gym, provide two 14 foot diameter ceiling fans (Big Ass Fans Model Basic 6) to enhance comfort with increased airflow. Also, inspect the existing mechanical system to identify any deficiencies, and then implement repairs to make the system operational.
    - a. Cooling Temperatures:
      - 1) 75 Degrees F DB, 63 Degrees F WB Inside Design
      - 2) 95 Degrees F DB, 67 Degrees F WB Outside Design
    - b. Heating Temperatures:
      - 1) 70 Degrees F DB Inside Design
      - 2) 20 Degrees F DB Outside Design
    - c. Lighting: 1.6 w/sf (this exceeds w/sf requirements of energy code to allow to install luminaires which are exempt from calculation requirements.)
    - d. Miscellaneous Electrical Load: 2 w/sf.

- e. Provide drawings with duct layout, exhaust fans, A/C units, size, and description of equipment, heating/cooling load calculations, equipment selections, etc. for review and for permit process. Coordinate ceiling diffuser locations with Architectural Drawings and Lighting Plan.
  - f. Exhaust airflow rates to be designed per current state ventilation code or ASHRAE recommendations, whichever is greater.
  - g. Provide calculations and installation details of equipment mounting to structure to conform to local seismic codes. Calculations and details to be included on Drawings as a part of submittal process.
2. Controls:
- a. Provide standalone, programmable t-stats for the mini split systems, time clocks for the new exhaust fans, and a wall mounted control panel for the new gym ceiling fans.
  - b. Materials and equipment used to be standard components, regularly manufactured for this and other systems and not custom designed specially for this project. Provide systems and components thoroughly tested and proven in actual use for at least 2 years.
  - c. Provide line and low voltage wiring for a complete and operable system. Wiring in accordance with local, State and National Codes.
3. Air Distribution Duct System:
- a. Provide ductwork, including collars, register boxes, fire dampers, fire/smoke dampers, exhaust fans, ventilation louvers, roof vents and screens, as well as dampers and other miscellaneous items not specifically mentioned but necessary for a complete installation. Apply latest Standards of SMACNA and/or ASHRAE with respect to sheet metal gauge and general construction for round and rectangular ducts.
- C. Calculations:
- 1. Submit heating and cooling load calculations per ASHRAE Standards for each HVAC zone.
  - 2. Submit structural calculations for seismic bracing of HVAC equipment and piping. Structural calculations to be signed by a Registered Engineer in the State of Oregon.

#### **1.05 SECTION INCLUDES**

- A. Work included in 23 00 00, HVAC Basic Requirements applies to Division 23, HVAC work to provide materials, labor, tools, permits, incidentals, and other services to provide and make ready for Owner's use of heating, ventilating and air conditioning systems for proposed project.
- B. Contract Documents include, but are not limited to, Specifications including Division 00, Procurement and Contracting Requirements and Division 01, General Requirements, Drawings, Addenda, Owner/Architect Agreement, and Owner/Contractor Agreement. Confirm requirements before commencement of work.
- C. Definitions:
- 1. Provide: To furnish and install, complete and ready for intended use.
  - 2. Furnish: Supply and deliver to project site, ready for unpacking, assembly and installation.
  - 3. Install: Includes unloading, unpacking, assembling, erecting, installation, applying, finishing, protecting, cleaning and similar operations at project site as required to complete items of work provided.
  - 4. Approved or Approved Equivalent: To possess the same performance qualities and characteristics and fulfill the utilitarian function without any decrease in quality, durability or longevity. For equipment/products defined by the Contractor as "equivalent", substitution requests must be submitted to Engineer for consideration, in accordance with Division 01, General Requirements, and approved by the Engineer prior to submitting bids for substituted items.
  - 5. Authority Having Jurisdiction (AHJ): Indicates reviewing authorities, including local fire marshal, Owner's insurance underwriter, Owner's representative, and other reviewing entity whose approval is required to obtain systems acceptance.

**1.06 RELATED SECTIONS**

- A. Contents of Section applies to Division 23, HVAC Contract Documents.
- B. Related Work:
  - 1. Additional conditions apply to this Division including, but not limited to:
    - a. Specifications including Division 00, Procurement and Contracting Requirements and Division 01, General Requirements.
    - b. Drawings
    - c. Addenda
    - d. Owner/Architect Agreement
    - e. Owner/Contractor Agreement
    - f. Codes, Standards, Public Ordinances and Permits

**1.07 REFERENCES AND STANDARDS**

- A. References and Standards per Division 01, General Requirements, individual Division 23, HVAC Sections and those listed in this Section.
- B. Codes to include latest adopted editions, including current amendments, supplements and local jurisdiction requirements in effect as of the date of the Contract Documents, of/from:
  - 1. State of Oregon:
    - a. OAR - Oregon Administrative Rules
    - b. OESC - Oregon Electrical Specialty Code
    - c. OFC - Oregon Fire Code
    - d. OMSC - Oregon Mechanical Specialty Code
    - e. OPSC - Oregon Plumbing Specialty Code
    - f. OSSC - Oregon Structural Specialty Code
    - g. OEESC - Oregon Energy Efficiency Specialty Code
    - h. Oregon Elevator Specialty Code
- C. Reference standards and guidelines include but are not limited to the latest adopted editions from:
  - 1. ABA - Architectural Barriers Act
  - 2. ABMA - American Bearing Manufacturers Association
  - 3. ADA - Americans with Disabilities Act
  - 4. AHRI - Air-Conditioning Heating & Refrigeration Institute
  - 5. AMCA - Air Movement and Control Association
  - 6. ANSI - American National Standards Institute
  - 7. ASCE - American Society of Civil Engineers
  - 8. ASHRAE - American Society of Heating, Refrigeration and Air-Conditioning Engineers
  - 9. ASHRAE Guideline 0, The Commissioning Process
  - 10. ASME - American Society of Mechanical Engineers
  - 11. ASPE - American Society of Plumbing Engineers
  - 12. ASSE - American Society of Sanitary Engineering
  - 13. ASTM - ASTM International
  - 14. AWWA - American Water Works Association
  - 15. CFR - Code of Federal Regulations
  - 16. CISPI - Cast Iron Soil Pipe Institute
  - 17. EPA - Environmental Protection Agency
  - 18. ETL - Electrical Testing Laboratories
  - 19. FM - FM Global
  - 20. GAMA - Gas Appliance Manufacturers Association
  - 21. HI - Hydraulic Institute Standards
  - 22. IAPMO - International Association of Plumbing & Mechanical Officials
  - 23. IFGC - International Fuel Gas Code
  - 24. ISO - International Organization for Standardization
  - 25. MSS - Manufacturers Standardization Society

26. NEC - National Electric Code
  27. NEMA - National Electrical Manufacturers Association
  28. NFPA - National Fire Protection Association
  29. NFGC - National Fuel Gas Code
  30. NRCA - National Roofing Contractors Association
  31. NSF - National Sanitation Foundation
  32. OSHA - Occupational Safety and Health Administration
  33. SMACNA - Sheet Metal and Air Conditioning Contractors' National Association, Inc.
  34. TEMA - Tubular Exchanger Manufacturers Association
  35. TIMA - Thermal Insulation Manufacturers Association
  36. UL - Underwriters Laboratories, Inc.
- D. See Division 23, HVAC individual Sections for additional references.
- E. Where code requirements are at variance with Contract Documents, meet code requirements as a minimum requirement and include costs necessary to meet these in Contract. Machinery and equipment are to comply with OSHA requirements, as currently revised and interpreted for equipment manufacturer requirements. Install equipment provided per manufacturer recommendations.
- F. Whenever this Specification calls for material, workmanship, arrangement or construction of higher quality and/or capacity than that required by governing codes, higher quality and/or capacity take precedence.
- G. Piping and duct insulation products to contain less than 0.1 percent by weight PBDE in all insulating materials.

#### **1.08 SUBMITTALS**

- A. See Division 01, General Requirements for Submittal Procedures as well as specific individual Division 23, HVAC Sections.
- B. Provide drawings in format and software release equal to the design documents. Drawings to be the same sheet size and scale as the Contract Documents.
- C. In addition:
1. "No Exception Taken" constitutes that review is for general conformance with the design concept expressed in the Contract Documents for the limited purpose of checking for conformance with information given. Any action is subject to the requirements of the Contract Documents. Contractor is responsible for the dimensions and quantity and will confirm and correlate at the job site, fabrication processes and techniques of construction, coordination of the work with that of all other trades, and the satisfactory performance of the work.
  2. Provide product submittals and shop drawings in electronic format only. Electronic format must be submitted via zip file via e-mail. For electronic format, provide one zip file per specification division containing a separate file for each Specification Section. Individual submittals sent piecemeal in a per Specification Section method will be returned without review or comment. All transmissions/submissions to be submitted to Architect. Deviations will be returned without review.
  3. Product Data: Provide Manufacturer's descriptive literature for products specified in Division 23, HVAC Sections.
  4. Identify/mark each submittal in detail. Note what differences, if any, exist between the submitted item and the specified item. Failure to identify the differences will be considered cause for disapproval. If differences are not identified and/or not discovered during the submittal review process, Contractor remains responsible for providing equipment and materials that meet the Specifications and Drawings.
    - a. Label submittal to match numbering/references as shown in Contract Documents. Highlight and label applicable information to individual equipment or cross out/remove extraneous data not applicable to submitted model. Clearly note options and accessories to be provided, including field installed items. Highlight connections by/to other trades.

- b. Include technical data, installation instructions and dimensioned drawings for products, fixtures, equipment and devices installed, furnished or provided. Reference individual Division 23, HVAC Specification Sections for specific items required in product data submittal outside of these requirements.
  - c. Provide pump curves, operation characteristics, capacities, ambient noise criteria, etc. for equipment.
  - d. For vibration isolation of equipment, list make and model selected with operating load and deflection.
  - e. See Division 23, HVAC individual Sections for additional submittal requirements outside of these requirements.
5. Maximum of two reviews of submittal package. Arrange for additional reviews and/or early review of long-lead items; Bear costs of these additional reviews at Engineer's hourly rates. Incomplete submittal packages/submittals will be returned to contractor without review.
6. Resubmission Requirements: Make corrections or changes in submittals as required, and in consideration of Engineer's comments. Identify Engineer's comments and provide an individual response to each of the Engineer's comments. Cloud changes in the submittals and further identify changes which are in response to Engineer's comments.
7. Structural/Seismic: Provide weights, dimensions, mounting requirements and like information required for mounting, seismic bracing, and support. Indicate manufacturer's installation and support requirements to meet Section 23 05 48, Vibration and Seismic Controls for HVAC Equipment. Provide engineered seismic drawings and equipment seismic certification. Equipment Importance Factor as specified in Division 01 and in Structural documents.
8. Trade Coordination: Include physical characteristics, electrical characteristics, device layout plans, wiring diagrams, and connections as required by Division 23, HVAC Coordination Documents. For equipment with electrical connections, furnish copy of approved submittal for inclusion in Division 26, Electrical submittals.
9. Make provisions for openings in building for admittance of equipment prior to start of construction or ordering of equipment.
10. Substitutions and Variation from Basis of Design:
  - a. The Basis of Design designated product establishes the qualities and characteristics for the evaluation of any comparable products by other listed acceptable manufacturers if included in this Specification or included in an approved Substitution Request as judged by the Design Professional.
  - b. If substitutions and/or equivalent equipment/products are being proposed, it is the responsibility of parties concerned, involved in, and furnishing the substitute and/or equivalent equipment to verify and compare the characteristics and requirements of that furnished to that specified and/or shown. If greater capacity and/or more materials and/or more labor is required for the rough-in, circuitry or connections than for the item specified and provided for, then provide compensation for additional charges required for the proper rough-in, circuitry and connections for the equipment being furnished. No additional charges above the Base Bid, including resulting charges for work performed under other Divisions, will be allowed for such revisions. Coordinate with the requirements of "Submittals". For any product marked "or approved equivalent", a substitution request must be submitted to Engineer for approval prior to purchase, delivery or installation.
11. Shop Drawings: Provide coordinated shop drawings which include physical characteristics of all systems, equipment, ductwork and piping layout plans, and control wiring diagrams. Reference individual Division 23, HVAC Specification Sections for additional requirements for shop drawings outside of these requirements.
  - a. Provide Shop Drawings indicating access panel locations for items that require Code or maintenance access, size and elevation for approval prior to installation.
12. Samples: Provide samples when requested by individual Sections.
13. Resubmission Requirements:

- a. Make any corrections or change in submittals when required. Provide submittals as specified. The engineer will not be required to edit and/or interpret the Contractor's submittals. Indicate changes for the resubmittal in a cover letter with reference to page(s) changed and reference response to comment. Cloud changes in the submittals.
  - 1) Resubmit for review until review indicates no exception taken or make "corrections as noted".
  - 2) When submitting drawings for Engineers re-review, clearly indicate changes on drawings and "cloud" any revisions. Submit a list describing each change.
14. Operation and Maintenance Manuals, Owners Instructions:
  - a. Submit, at one time, electronic files (PDF format) on CD/DVD of manufacturer's operation and maintenance instruction manuals and parts lists for equipment or items requiring servicing. Include valve charts. Submit data when work is substantially complete and in same order format as submittals. Include name and location of source parts and service for each piece of equipment.
    - 1) Include copy of approved submittal data along with submittal review letters received from Engineer. Data to clearly indicate installed equipment model numbers. Delete or cross out data pertaining to other equipment not specific to this project.
    - 2) Include copy of manufacturer's standard Operations and Maintenance for equipment. At front of each tab, provide routine maintenance documentation for scheduled equipment. Include manufacturer's recommended maintenance schedule and highlight maintenance required to maintain warranty. Furnish list of routine maintenance parts, including part numbers, sizes, quantities, relevant to each piece of equipment: belts, motors, lubricants, and filters.
    - 3) Include Warranty per Division 00, Procurement and Contracting Requirements and Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Sections.
    - 4) Include product certificates of warranties and guarantees.
    - 5) Include copy of complete parts list for equipment. Include available exploded views of assemblies and sub assemblies.
    - 6) Include copy of startup and test reports specific to each piece of equipment.
    - 7) Include copy of final air and water systems balancing log along with pump, fan and distribution system operating data.
    - 8) Include commissioning reports.
    - 9) Include copy of valve charts/schedules.
    - 10) Engineer will return incomplete documentation without review. Engineer will provide one set of review comments in Submittal Review format. Contractor must arrange for additional reviews; Contractor to bear costs for additional reviews at Engineer's hourly rates.
  - b. Thoroughly instruct Owner in proper operation of equipment and systems. Where noted in individual Sections, training will include classroom instruction with applicable training aids and systems demonstrations. Field instruction per Section 23 00 00, HVAC Basic Requirements Article titled "Demonstration".
  - c. Copies of certificates of code authority inspections, acceptance, code required acceptance tests, letter of conformance and other special guarantees, certificates of warranties, specified elsewhere or indicated on Drawings.
15. Record Drawings:
  - a. Maintain at site at least one set of drawings for recording "As-constructed" conditions. Indicate on drawings changes to original documents by referencing revision document, and include buried elements, location of cleanouts, and location of concealed mechanical items. Include items changed by field orders, supplemental instructions, and constructed conditions.
  - b. Record Drawings are to include equipment and fixture/connection schedules, control dampers, fire smoke dampers, fire dampers, valves, bottom of pipe, duct and



equipment elevations and dimensioned locations for all distribution systems (hydronic and air). Invert elevations and dimensioned locations for underground systems below grade to 5-feet outside building that accurately reflect "as constructed or installed" for project.

- c. At completion of project, input changes to original project CAD Drawings and make one set of black-line drawings created from CAD Files in version/release equal to contract drawings. Submit CAD disk and drawings upon substantial completion.
- d. See Division 23, HVAC individual Sections for additional items to include in record drawings.

#### **1.09 QUALITY ASSURANCE**

- A. Regulatory Requirements: Work and materials installed to conform with all local, State, Federal and other applicable laws and regulations.
- B. Drawings are intended to be diagrammatic and reflect the Basis of Design manufacturer's equipment. They are not intended to show every item in its exact dimensions, or details of equipment or proposed systems layout. Verify actual dimensions of systems (i.e., piping) and equipment proposed to assure that systems and equipment will fit in available space. Contractor is responsible for design and construction costs incurred for equipment other than Basis of Design, including, but not limited to, architectural, structural, electrical, HVAC, fire sprinkler, and plumbing systems.
- C. Manufacturer's Instructions: Follow manufacturer's written instructions. If in conflict with Contract Documents, obtain clarification. Notify Engineer/Architect, in writing, before starting work.
- D. Items shown on Drawings are not necessarily included in Specifications or vice versa. Confirm requirements in all Contract Documents.
- E. Provide products that are UL listed.
- F. ASME Compliance: ASME listed water heaters and boilers with an input of 200,000 BTUH and higher, hot water storage tanks which exceed 120 gallons, and hot water expansion tanks which are connected to ASME rated equipment or required by code or local jurisdiction.
- G. Provide safety controls required by National Boiler Code (ASME CSD 1) for boilers and water heaters with an input of 400,000 BTUH and higher.

#### **1.10 WARRANTY**

- A. Provide written warranty covering the work for a period of one year from date of Substantial Completion in accordance with Division 00, Contracting and Procurement Requirements, Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Division 23, HVAC Sections.
- B. Sections under this Division can require additional and/or extended warranties that apply beyond basic warranty under Division 01, General Requirements and the General Conditions. Confirm requirements in all Contract Documents.

#### **1.11 COORDINATION DOCUMENTS**

- A. Prior to construction, coordinate installation and location of HVAC equipment, ductwork, grilles, diffusers, piping, equipment, fire sprinklers, plumbing, cable trays, lights, and electrical services with architectural and structural requirements, and other trades (including ceiling suspension, and tile systems), and provide maintenance access requirements. Coordinate with submitted architectural systems (i.e. roofing, ceiling, finishes) and structural systems as submitted, including footings and foundation. Identify zone of influence from footings and ensure systems are not routed within the zone of influence.
- B. Advise Architect in event a conflict occurs in location or connection of equipment. Bear costs resulting from failure to properly coordinate installation or failure to advise Architect of conflict.
- C. Verify in field exact size, location, invert, and clearances regarding existing material, equipment and apparatus, and advise Architect of discrepancies between that indicated on Drawings and that existing in field prior to installation related thereto.

- D. Submit final Coordination Drawings with changes as Record Drawings at completion of project.

## **PART 2 - PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Provide like items from one manufacturer, including but not limited to pumps, fans, valves, control devices, air handlers, vibration isolation devices, etc.

### **2.02 MATERIALS**

- A. Base contract upon furnishing materials as specified. Materials, equipment, and fixtures used for construction are to be new, latest products as listed in manufacturer's printed catalog data and are to be UL approved or have adequate approval or be acceptable by State, County, and City authorities.
- B. Articles, fixtures, and equipment of a kind to be standard product of one manufacturer.
- C. Names and manufacturer's names denote character and quality of equipment desired and are not to be construed as limiting competition.
- D. Hazardous Materials:
  - 1. Comply with local, State of Oregon, and Federal regulations relating to hazardous materials.
  - 2. Comply with Division 00, Procurement and Contracting Requirements and Division 01, General Requirements for this project relating to hazardous materials.
  - 3. Do not use any materials containing a hazardous substance. If hazardous materials are encountered, do not disturb; immediately notify Owner and Architect. Hazardous materials will be removed by Owner under separate contract.

### **2.03 ACCESS PANELS**

- A. See Division 01, General Requirements and Division 08, Openings for products and installation requirements.
- B. Confirm Access Panel requirements in Division 01, General Requirements, Division 08, Openings and individual Division 23, HVAC Sections. In absence of specific requirements in Division 01, General Requirements, comply with the following:
  - 1. Provide flush mounting access panels for service of systems and individual components requiring maintenance or inspection. Where access panels are located in fire-rated assemblies of building, rate access panels accordingly.
    - a. Ceiling access panels to be minimum 24-inch by 24-inch required and approved size.
    - b. Wall access panels to be minimum of 12-inch by 12-inch required and approved size.
    - c. Provide two keys for each set of keyed cylinder type locks.
    - d. Manufacturers and Models:
      - 1) Drywall: Karp KDW.
      - 2) Plaster: Karp DSC-214PL.
      - 3) Masonry: Karp DSC-214M.
      - 4) 2 hour rated: Karp KPF-350FR.
      - 5) Manufacturers: Milcor, Elmdor, Acudor or approved equivalent.

## **PART 3 - EXECUTION**

### **3.01 ACCESSIBILITY AND INSTALLATION**

- A. Confirm Accessibility and Installation requirements in Division 00, Procurement and Contracting Requirements and Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Division 23, HVAC Sections.
- B. Install equipment having components requiring access (i.e., drain pans, drains, control operators, valves, motors and vibration isolation devices) so that they may be serviced, reset, replaced or recalibrated by service people with normal service tools and equipment. Do not install equipment in obvious passageways, doorways, scuttles or crawlspace which would impede or block intended usage.

- C. Install equipment and products complete as directed by manufacturer's installation instructions including all appurtenances recommended in manufacturer's installation instructions, at no additional charge to Owner. Obtain installation instructions from manufacturer prior to rough-in of equipment and examine instructions thoroughly. When requirements of installation instructions conflict with Contract Documents, request clarification from Architect prior to proceeding with installation. This includes proper installation methods, sequencing and coordination with other trades and disciplines.
- D. Earthwork:
  - 1. Confirm Earthwork requirements in Contract Documents. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
    - a. Perform excavation, dewatering, shoring, bedding, and backfill required for installation of work in this Division in accordance with related earthwork Sections. Contact utilities and locate existing utilities prior to excavation. Repair any work damaged during excavation or backfilling.
    - b. Excavation: Do not excavate under footings, foundation bases, or retaining walls.
    - c. Provide protection of underground systems. Review the project Geotechnical Report for references to corrosive or deleterious soils which will reduce the performance or service life of underground systems materials.
- E. Firestopping:
  - 1. Confirm Firestopping requirements in Division 07, Thermal and Moisture Protection. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
    - a. Coordinate location and protection level of fire and/or smoke rated walls, ceilings, and floors. When these assemblies are penetrated, seal around piping, ductwork and equipment with approved firestopping material. Install firestopping material complete as directed by manufacturer's installation instructions. Meet requirements of ASTM E814, Standard Test Method for Fire Tests of Through-Penetration Fire Stops.
- F. Pipe Installation:
  - 1. Provide installation of piping systems coordinated to account for expansion and contraction of piping materials and building, as well as anticipated settlement or shrinkage of building. Install work to prevent damage to piping, equipment, and building and its contents. Provide piping offsets, loops, seismic flexible joints, expansion joints, sleeves, anchors or other means to control pipe movement and minimize forces on piping. Verify anticipated settlement and/or shrinkage of building with Project Structural Engineer. Verify construction phasing, type of building construction products and rating for coordinating installation of piping systems.
  - 2. Include provisions for servicing and removal of equipment without dismantling piping.
- G. Plenums:
  - 1. Plenums: Materials within plenums shall be noncombustible or shall have a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E 84 or UL 723. Immediately notify Architect / Engineer of any discrepancy.

### **3.02 SEISMIC CONTROL**

- A. Confirm Seismic Control requirements in Division 01, General Requirements, Structural documents, and individual Division 23 HVAC Sections.
- B. General:
  - 1. Earthquake resistant designs for HVAC (Division 23) equipment and distribution, i.e. motors, ductwork, piping, equipment, etc. to conform to regulations of jurisdiction having authority.
  - 2. Restraints which are used to prevent disruption of function of piece of equipment because of application of horizontal force to be such that forces are carried to frame of structure in such a way that frame will not be deflected when apparatus is attached to a mounting base and equipment pad, or to structure in normal way, utilizing attachments provided. Secure

- equipment and distribution systems to withstand a force in direction equal to value defined by jurisdiction having authority.
3. Provide stamped Shop Drawings from licensed Structural Engineer of seismic bracing and seismic movement assemblies for piping equipment and water heaters. Submit Shop Drawings along with equipment submittals.
  4. Provide stamped Shop Drawings from licensed Structural Engineer of seismic flexible joints for piping and crossing building expansion or seismic joints. Submit Shop Drawings along with seismic bracing details.
- C. Piping and Ductwork:
1. Per "Seismic Restraints Manual Guidelines for Mechanical Systems" latest edition published by SMACNA or local requirements.
- D. Provide means to prohibit excessive motion of mechanical equipment during earthquake.

### **3.03 REVIEW AND OBSERVATION**

- A. Confirm Review and Observation requirements in Division 00, Procurement and Contracting Requirements, Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Division 23, HVAC Sections.
- B. Notify Architect, in writing, at following stages of construction so that they may, at their option, visit site for review and construction observation:
1. Underground system installation prior to backfilling.
  2. Prior to covering walls.
  3. Prior to ceiling cover/installation.
  4. After major equipment is installed.
  5. When main systems, or portions of, are being tested and ready for inspection by AHJ.
- C. Final Punch:
1. Prior to requesting a final punch visit from the Engineer, request from Engineer the Mechanical Precloseout Checklist, complete the checklist confirming completion of systems' installation, and return to Engineer. Request a final punch visit from the Engineer, upon Engineer's acceptance that the mechanical systems are ready for final punch.
  2. Costs incurred by additional trips required due to incomplete systems will be the responsibility of the Contractor.

### **3.04 CONTINUITY OF SERVICE**

- A. Confirm requirements in Division 00, Procurement and Contracting Requirements and Division 01, General Requirements. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
1. During remodeling or addition to existing structures, while existing structure is occupied, current services to remain intact until new construction, facilities or equipment is installed.
  2. Prior to changing over to new service, verify that every item is thoroughly prepared. Install new piping and ductwork, and wiring to point of connection. Where existing systems are being utilized, clean existing distribution systems (ductwork, piping, fans, air handlers) prior to connecting new ductwork or piping.
  3. Coordinate transfer time to new service with Owner. If required, perform transfer during off peak hours. Once changeover is started, pursue to its completion to keep interference to a minimum.
    - a. If overtime is necessary, there will be no allowance made by Owner for extra expense for such overtime or shift work.
  4. Organize work to minimize duration of power interruption.

### **3.05 CUTTING AND PATCHING**

- A. Confirm Cutting and Patching requirements in Division 00, Procurement and Contracting Requirements and Division 01, General Requirements. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
1. Proposed floor cutting/core drilling/sleeve locations to be approved by Project Structural Engineer. Submit proposed locations to Architect/Project Structural Engineer. Where slabs

are of post tension construction, perform x-ray scan of proposed penetration locations and submit scan results including proposed penetration locations to Project Structural Engineer/Architect for approval. Where slabs are of waffle type construction, show column cap extent and cell locations relative to proposed penetration(s).

2. Cutting, patching and repairing for work specified in this Division including plastering, masonry work, concrete work, carpentry work, and painting included under this Section will be performed by skilled craftsmen of each respective trade in conformance with appropriate Division of Work.
3. Additional openings required in building construction to be made by drilling or cutting. Use of jack hammer is specifically prohibited. Patch openings in and through concrete and masonry with grout.
4. Restore new or existing work that is cut and/or damaged to original condition. Patch and repair specifically where existing items have been removed. This includes repairing and painting walls, ceilings, etc. where existing conduit and devices are removed as part of this project. Where alterations disturb lawns, paving, and walks, surfaces to be repaired, refinished and left in condition matching existing prior to commencement of work.
5. Additional work required by lack of proper coordination will be provided at no additional cost to the Owner.

### **3.06 EQUIPMENT SELECTION AND SERVICEABILITY**

- A. Replace or reposition equipment which is too large or located incorrectly to permit servicing, at no additional cost to Owner.
- B. Maintain design intent where equipment other than as shown as Basis of Design in Contract Documents is provided. Where equipment requires ductwork or piping arrangement, controls/control diagrams, or sequencing different from that indicated in Contract Documents, provide at no additional cost to Owner.

### **3.07 DELIVERY, STORAGE AND HANDLING**

- A. Confirm requirements in Division 00, Procurement and Contracting Requirements and Division 01, General Requirements. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
  1. Handle materials delivered to project site with care to avoid damage. Store materials on site inside building or protected from weather, dirt and construction dust. Insulation and lining that becomes wet from improper storage and handling to be replaced before installation. Products and/or materials that become damaged due to water, dirt, and/or dust as a result of improper storage to be replaced before installation.
  2. Protect equipment and pipe to avoid damage. Close pipe openings with caps or plugs. Keep motors and bearings in watertight and dustproof covers during entire course of installation.
  3. Protect bright finished shafts, bearing housings and similar items until in service.

### **3.08 DEMONSTRATION**

- A. Confirm Demonstration requirements in Division 00, Procurement and Contracting Requirements and Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Division 23, HVAC Sections.
- B. Upon completion of work and adjustment of equipment and test systems, demonstrate to Owner's Representative, Architect and Engineer that equipment furnished and installed or connected under provisions of these Specifications functions in manner required. Provide field instruction to Owner's Maintenance Staff as specified in Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Division 23, HVAC Sections.
- C. Manufacturer's Field Services: Furnish services of a qualified person at time approved by Owner, to instruct maintenance personnel, correct defects or deficiencies, and demonstrate to satisfaction of Owner that entire system is operating in satisfactory manner and complies with requirements of other trades that may be required to complete work. Complete instruction and demonstration prior to final job site observations.

**3.09 CLEANING**

- A. Confirm Cleaning requirements in Division 00, Procurement and Contracting Requirements, Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Division 23, HVAC Sections.
- B. Upon completion of installation, thoroughly clean exposed portions of equipment, removing temporary labels and traces of foreign substances. Throughout work, remove construction debris and surplus materials accumulated during work.

**3.10 INSTALLATION**

- A. Confirm Installation requirements in Division 00, Procurement and Contracting Requirements, Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Division 23, HVAC Sections.
- B. Install equipment and fixtures in accordance with manufacturer's installation instructions, plumb and level and firmly anchored to vibration isolators. Maintain manufacturer's recommended clearances.
- C. Start up equipment, in accordance with manufacturer's start-up instructions, and in presence of manufacturer's representative. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
  - 1. Do not place equipment in sustained operation prior to initial balancing of HVAC systems.
- D. Provide miscellaneous supports/metals required for installation of equipment, piping and ductwork.

**3.11 PAINTING**

- A. Confirm Painting requirements in Division 01, General Requirements and Division 09, Finishes. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
  - 1. Ferrous Metal: After completion of work, thoroughly clean and paint exposed supports constructed of ferrous metal surfaces in mechanical rooms, i.e., hangers, hanger rods, equipment stands, with one coat of black asphalt varnish for exterior or black enamel for interior, suitable for hot surfaces.
  - 2. After acceptance by Authority Having Jurisdiction (AHJ), In a mechanical room, on roof or other exposed areas, machinery and equipment not painted with enamel to receive two coats of primer and one coat of rustproof enamel, colors as selected by Architect.
  - 3. See individual equipment Specifications for other painting.
  - 4. Structural Steel: Repair damage to structural steel finishes or finishes of other materials damaged by cutting, welding or patching to match original.
  - 5. Piping and Ductwork: Clean, primer coat and paint exposed piping and ductwork on roof or at other exterior locations with two coats paint suitable for metallic surfaces and exterior exposures. Color selected by Architect.
  - 6. Covers: Covers such as manholes, cleanouts and the like will be furnished with finishes which resist corrosion and rust.

**3.12 DEMOLITION**

- A. Confirm requirements in Division 01, General Requirements and Division 02, Existing Conditions. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
  - 1. Scope:
    - a. It is the intent of these documents to provide necessary information and adjustments to the HVAC system required to meet code, and accommodate installation of new work.
    - b. Coordinate with Owner so that work can be scheduled not to interrupt operations, normal activities, building access or access to different areas.
    - c. Existing Conditions: Determine exact location of existing utilities and equipment before commencing work, compensate Owner for damages caused by failure to

exactly locate and preserve utilities. Replace damaged items with new material to match existing. Promptly notify Owner if utilities are found which are not shown on Drawings.

2. Equipment: Unless otherwise directed, equipment, fixtures, or fittings being removed as part of demolition process are Owner's property. Remove other items not scheduled to be reused or relocated from job site as directed by Owner.
3. Unless specifically indicated on Drawings, remove exposed, unused ductwork and piping to behind finished surfaces (floor, walls, ceilings, etc.). Cap and patch surfaces to match surrounding finish.
4. Unless specifically indicated on Drawings, remove unused equipment, fixtures, fittings, rough-ins, and connectors. Removal is to be to a point behind finished surfaces (floors, walls, and ceilings).

### **3.13 ACCEPTANCE**

- A. Confirm requirements in Division 00, Procurement and Contracting Requirements and Division 01, General Requirements. In absence of specific requirements, comply with individual Division 23, HVAC Sections and the following:
  1. System cannot be considered for acceptance until work is completed and demonstrated to Architect that installation is in strict compliance with Specifications, Drawings and manufacturer's installation instructions, particularly in reference to following:
    - a. Testing and Balancing Reports
    - b. Cleaning
    - c. Operation and Maintenance Manuals
    - d. Training of Operating Personnel
    - e. Record Drawings
    - f. Warranty and Guaranty Certificates
    - g. Start-up/Test Document
    - h. Commissioning Reports

### **3.14 FIELD QUALITY CONTROL**

- A. Confirm Field Quality Control requirements in Division 01, General Requirements, Section 23 00 00, HVAC Basic Requirements and individual Division 23, HVAC Sections.
- B. Tests:
  1. Conduct tests of equipment and systems to demonstrate compliance with requirements specified. Reference individual Specification Sections for required tests. Document tests and include in Operation and Maintenance Manuals.
  2. During site evaluations by Architect or Engineer, provide appropriate personnel with tools to remove and replace trims, covers, and devices so that proper evaluation of installation can be performed.

### **3.15 LETTER OF CONFORMANCE**

- A. Provide Letter of Conformance, copies of manufacturers' warranties and extended warranties with a statement that HVAC items were installed in accordance with manufacturer's recommendations, UL listings and FM Global approvals. Include Letter of Conformance, copies of manufacturers' warranties and extended warranties in Operation and Maintenance Manuals.

### **3.16 ELECTRICAL INTERLOCKS**

- A. Where equipment motors are to be electrically interlocked with other equipment for simultaneous operation, utilize equipment wiring diagrams to coordinate with electrical systems so that proper wiring of equipment involved is affected.

**3.17 TEMPORARY HEATING, COOLING AND HUMIDITY CONTROL**

- A. Provide temporary heating, cooling, controls, humidification and dehumidification as required to facilitate the construction of the project. Size and select temporary system based on the requirements of the various trades during construction. This includes, but is not limited to, drywall, case work, wood flooring and wood finishes that are subject to warping. Size and install system to prevent mold growth. Coordinate the location of the temporary system. The house system can be used. Develop a procedure for how the house system will be used including a sketch depicting the house system, how filtration will be used to prevent construction debris from entering the system and how often the filters will be changed, how the ductwork will be cleaned after use to ensure a clean system is turned over to the Owner and how the units are sized. Submit this procedure to the Mechanical Engineer for review. Follow National Air Duct Cleaners Association (NADCA) duct cleaning procedures and guidelines. Warranties for the house system, if new, to commence when the Owner moves in if house system is used as the means to maintain the climate within the building during construction. Include this warranty requirement in the original bid or proposal amount. Coordinate and provide any temporary power, controls, ductwork, piping, plumbing anchorage, miscellaneous steel and structural supports required to support the temporary system. Installation of the system to comply with all applicable codes and be acceptable to the Authority Having Jurisdiction (AHJ).

**END OF SECTION**



**SECTION 23 05 13****COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT****PART 1 - GENERAL****1.01 SUMMARY**

- A. Work Included:
  - 1. Starters
  - 2. Shaft Grounding
  - 3. Motors

**1.02 RELATED SECTIONS**

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

**1.03 REFERENCES AND STANDARDS**

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
  - 1. NEMA Premium Efficiency
  - 2. Energy Policy Act (EPACT), latest applicable version(s) for minimum motor efficiencies.

**1.04 SUBMITTALS**

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

**1.05 QUALITY ASSURANCE**

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
  - 1. Field Installed Motors: Installed motors to be of single type, from one source and from a single manufacturer.
  - 2. Electrical components and materials to be UL and ETL listed/labeled as suitable for location and use.

**1.06 WARRANTY**

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
  - 1. For motors 50 HP and larger, provide 5-year manufacturer's limited warranty from date of substantial completion.

**PART 2 - PRODUCTS****2.01 MANUFACTURERS**

- A. Starters:
  - 1. Cerus
  - 2. Eaton Electrical
  - 3. General Electric
  - 4. Siemens
  - 5. Schneider Electric/Square D
  - 6. Or approved equivalent.
- B. Shaft Grounding:
  - 1. Shaft Grounding Inc.
  - 2. Aegis SGR Bearing Protection Ring
  - 3. Or approved equivalent.
- C. Motors:

1. Lincoln Motor
2. Century Electric Motors (formerly A.O. Smith Electrical Products)
3. Baldor Electric
4. General Electric
5. Toshiba
6. Exception: Motors integral to equipment efficiency listing (EER, COP, etc.) per listing agency.
7. Or approved equivalent.

## **2.02 STARTERS**

- A. Single Phase Motors:
  1. Manual across-the-line starting switch having toggle-operated switch pilot running light and built-in thermal overload device with heating element rated not more than 115 percent motor full load current indicated on name plate of motor to be protected. Surface mount starters. Provide NEMA-1 enclosure.
  2. Overload relays to be melting alloy type with a replaceable control circuit module. Thermal units to be interchangeable. Starter to be non operative if thermal unit is removed.
  3. Single-phase motors with automatic controls. Provide motor-rated relay with coils rated for control voltage.
- B. Starters up to Size 8 to be suitable for the addition of a minimum of three external auxiliary contacts (normally open or normally closed). Contactor, coils, and relays to perform the control functions of the associated equipment and control sequence.
- C. Three Phase Motors up to and Including 15 HP:
  1. Provide enclosed type magnetic across-the-line starter with thermal overload and undervoltage protection.
  2. Operator: "Start-Stop" pushbutton, except where automatic control is indicated on Drawings or specified. Then provide "Hand-Off-Auto" selector switch.
  3. Starters for 3-phase motors to have overload protection in each of the three legs, with external manual reset.
  4. Unless indicated on Drawings or in Specifications, furnish motor starters with a neon pilot light. Neon lights are required for exhaust fan switches.
  5. Equip starters with integral transformer and coil for control circuit. Coordinate coil voltage with control voltage.
- D. For Three Phase Motors Greater than 15 HP:
  1. Provide combination starter and fused safety disconnect integral in the same enclosure. Utilize Type 'RK' or 'L' fuses. Provide fuse block with rejection type fuse holders. Size fuses per motor manufacturer's recommendations.
  2. Provide a solid-state reduced voltage starter, consisting of power Section, one-piece removable printed circuit logic board and field wiring interface terminals. Logic board uses quick disconnect plug-in connectors for current transformers inputs, line-and-load voltage inputs, SCR gate firing output circuits and status panel. 3-phase current sensing via current transformers. Class 10 electronic overload protection.
  3. Motor starters to include the following protections:
    - a. Inverse time running overcurrent protection.
    - b. 250 percent to 500 percent current limit adjustment.
    - c. Minimum and maximum voltage adjustments.
    - d. Voltage stability adjustment.
    - e. Single-phase protection with built-in short-time delay.
    - f. Undervoltage protection with built-in short time delay.
    - g. MOV surge suppression protection of SCRs rated 10 percent above the rated voltage.
    - h. Phase sequence protection.
  4. Display: Door-mounted status LCD alphanumeric or LED display indicating run, undervoltage, phase loss, phase current unbalance, overcurrent trip, overtemperature, current limit, end of ramp, and incorrect phase rotation.

5. Enclosure: NEMA 12. Operator: "Start-Stop" pushbutton, except where automatic control is indicated on Drawings or specified, then provide "Hand-Off-Auto" selector switch
6. Input/Output Relays: Provide relays as required to provide the control sequence.
7. UL 508 listed.

### **2.03 SHAFT GROUNDING**

- A. Variable Speed Motor Shaft Grounding: Shaft grounding ring.

### **2.04 MOTORS**

- A. Construction:
1. Open drip-proof type except where specifically noted otherwise.
  2. Design for continuous operation in 40 degrees C environment.
  3. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
  4. Built-in thermal overload protection or externally protected with separate over-load with low-voltage release or lock-out. Quick trip device on hermetically sealed motors.
  5. Service Factor: 1.15 for poly-phase motors except 1.25 for motors associated with shaft pressurization system fans and 1.35 for single phase motors.
  6. Efficiency: Provide NEMA Premium Efficiency motors.
  7. Motors used in conjunction with variable speed drives: Variable torque type matched for the full operating range of the variable frequency drive. As a minimum, motors to have Class F insulation, winding insulation rated for 1000 Volts and insulated bearings to prevent high frequency ground path. Loads not-to-exceed 80 percent of nameplate rating
- B. Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, efficiency.
- C. Wiring Terminations:
1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Coordinate conductor sizes with Division 26, Electrical. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
  2. For fractional horsepower motors where connection is made directly, provide conduit connection in end frame.
- D. Single Phase Power, Split Phase Motors:
1. Starting Torque: Less than 150 percent of full load torque.
  2. Starting Current: Up to seven times full load current.
  3. Breakdown Torque: Approximately 200 percent of full load torque.
  4. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.
  5. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.
- E. Single Phase Power, Permanent-Split Capacitor Motors:
1. Starting Torque: Exceeding one fourth of full load torque.
  2. Starting Current: Up to six times full load current.
  3. Multiple Speed: Through tapped windings.
  4. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.
- F. Single Phase Power, Capacitor Start Motors:
1. Starting Torque: Three times full load torque.
  2. Starting Current: Less than five times full load current.
  3. Pull-up Torque: Up to 350 percent of full load torque.
  4. Breakdown Torque: Approximately 250 percent of full load torque.

5. Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
  6. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve bearings.
  7. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.
- G. Three Phase Power, Squirrel Cage Motors:
1. Starting Torque: Between 1 and 1-1/2 times full load torque.
  2. Starting Current: Six times full load current.
  3. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.
  4. Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B motors.
  5. Insulation System: NEMA Class B or better. Use class F insulation when motors are controlled by a VFD.
  6. Testing Procedure: In accordance with IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.
  7. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
  8. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors imbedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter.
  9. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum ABMA STD 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
  10. Sound Power Levels: To NEMA MG 1.
  11. Weatherproof Epoxy Treated Motors: Epoxy coat windings with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.
  12. Nominal Efficiency: Meet or exceed NEMA Premium Efficiency rating when tested in accordance with IEEE 112.
  13. Nominal Power Factor: Minimum at full load and rated voltage when tested in accordance with IEEE 112.

### **PART 3 - EXECUTION**

#### **3.01 GENERAL INSTALLATION**

- A. Coordinate location of disconnect and starter or motor controller. Combination starter/disconnects may be used in lieu of separate items.
- B. Explosion-Proof Motors: UL approved and labeled for hazard classification, with over temperature protection.
- C. Unless otherwise indicated, motors 1-HP and larger to meet/exceed NEMA Premium Efficiency and latest EPACK.
- D. Exception: Motors less than 250 watts, for intermittent service, motors furnished with equipment manufacturer's standard package equipment need not conform to these specifications.
- E. Single phase motors for air compressors and pumps: Capacitor start type.
- F. Motors located in exterior locations or wet air streams are to be of totally enclosed type.
- G. Motors located wet/wash-down locations: Totally enclosed weatherproof epoxy-sealed type.
- H. Disconnects: Provided by Division 26, Electrical unless specified otherwise.
- I. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

### 3.02 STARTER INSTALLATION

- A. Install starters in accordance with manufacturer's instructions.
- B. Coordinate disconnect requirements and location with Division 26, Electrical if not integral to starter. If starter is installed out of line of sight of motor, provide additional disconnect at motor per code.
- C. Provide NEMA housing appropriate to installation location.
- D. Provide supports and install securely, in neat and workmanlike manner, as specified in NECA 1.
- E. Meet mounting height and accessible location requirements per local code.
- F. Provide fuses for fusible switches.
- G. Select and install overload heater elements in motor starters to match installed motor characteristics.
- H. Single phase 120 Volt starter: if not furnished as single packaged controller/disconnect, provide contactors, relays, wiring and devices necessary to match sequence of operation for equipment.

### 3.03 SHAFT GROUNDING INSTALLATION

- A. Provide shaft grounding assembly on motors controlled by variable frequency drive. Shaft grounding device to be in the form of brush that resides on the motor shaft. Brush assembly capable of tolerating misalignment and maintaining rotating contact throughout the motors life.
- B. Material: Material used in the grounding assembly stable material commonly used within industry that is not believed to constitute a hazardous material under Occupational Safety & Health Administration (OSHA) regulations.
- C. Brushes: Specifically developed carbon compounds of sustained performance with sear life expectancy of 3 years minimum.
- D. Seals: Sealed type to keep contaminants from entering the shaft grounding system in wet or severe environment applications.
- E. Shaft Grounding Assembly: For clean room air handling systems, use the type that contains the wear products within a special enclosure within the shaft grounding system.
- F. Shaft grounding assembly installation not to affect the motor manufacturer warranty. Where the severe environment conditions require application of the shaft grounding types that are screwed into the motor shaft, the installation of the shaft grounding system performed either by the motor manufacturer or by the motor manufacturer authorized facility.
- G. Bond the brush to the closest ground point using code sized green insulated stranded copper conductor per manufacturer instructions.
- H. Test and verify the performance of the assembly to ensure that under no conditions the shaft exceeds 3 volts.
- I. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- J. Check line voltage and phase and ensure agreement with nameplate.
- K. Verify motor rotation.

### 3.04 MOTOR INSTALLATION

- A. Electrical Service: Power wiring from source to motor termination under Division 26, Electrical.
- B. Install in accordance with manufacturer's instructions. Coordinate with starter or variable speed controller with control sequence to provide necessary starter accessories.
- C. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- D. Check line voltage and phase and ensure agreement with nameplate.
- E. Verify motor rotation.
- F. Field Quality Control:
  - 1. Prepare for acceptance tests as follows:

- a. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
  - b. Test interlocks and control features for proper operation.
  - c. Verify that current in each phase is within nameplate rating.
- 2. Testing: Perform the following field quality-control testing:
  - a. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.15.1. Certify compliance with test parameters.
  - b. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- 3. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
  - a. Inspect field-assembled components, equipment installation, and piping and electrical connections for compliance with requirements.
  - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  - c. Verify bearing lubrication.
  - d. Verify proper motor rotation.
  - e. Test Reports: Prepare a written report to record the following test procedures used:
    - 1) Test results that comply with requirements.
    - 2) Test results that do not comply with requirements and corrective action taken to achieve compliance.
- G. Align motors, bases, shafts, pulleys and belts. Tension belts according to manufacturer's written instructions.
- H. Clean motors, on completion of installation, according to manufacturer's written instructions.

**END OF SECTION**

**SECTION 23 05 29****HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT****PART 1 - GENERAL****1.01 SUMMARY**

- A. Work Included:
  - 1. Hangers and Supports for HVAC Piping, Ductwork and Equipment
  - 2. Wall and Floor Sleeves
  - 3. Building Attachments
  - 4. Flashing
  - 5. Miscellaneous Metal and Materials

**1.02 RELATED SECTIONS**

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

**1.03 REFERENCES AND STANDARDS**

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
  - 1. ASCE 7-10, Minimum Design Loads for Buildings and Other Structures.
  - 2. Terminology: As defined in MSS SP-90 "Guidelines on Terminology for Pipe Hangers and Supports".
  - 3. Install ductwork and piping per SMACNA's requirements.
  - 4. Hanger spacing installation and attachment to meet all manufacturer's requirements and MSS SP-58.

**1.04 SUBMITTALS**

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

**1.05 QUALITY ASSURANCE**

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
  - 1. Welding:
    - a. Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications".
  - 2. Welding for Hangers:
    - a. Qualify procedures and personnel according to AWS D9.1, Sheet Metal Welding Code for duct joint and seam welding.
  - 3. Engineering Responsibility:
    - a. Design and preparation of Shop Drawings and calculations for each multiple pipe support, trapeze, duct support equipment hangers/supports, and seismic restraint by a qualified Structural Professional Engineer.
      - 1) Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of hangers and supports that are similar to those indicated for this Project in material, design, and extent.
  - 4. Manufacturers regularly engaged in the manufacture of bolted metal framing support systems, whose products have been in satisfactory use in similar service for not less than 10 years.
  - 5. Support systems to be supplied by a single manufacturer.

**1.06 WARRANTY**

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

**1.07 PERFORMANCE REQUIREMENTS**

- A. Provide pipe, ductwork and equipment hangers and supports in accordance with the following:
  - 1. When supports, anchorages, and seismic restraints for equipment, and supports, anchorages, and seismic restraints for conduit, piping, and ductwork are not shown on the Drawings, the contractor is responsible for their design.
  - 2. Connections to structural framing not to introduce twisting, torsion, or lateral bending in the framing members. Provide supplementary steel as required.
- B. Engineered Support Systems:
  - 1. Support frames such as pipe racks or stanchions for piping, ductwork, and equipment which provide support from below.
  - 2. Equipment, ductwork and piping support frame anchorage to supporting slab or structure.
- C. Provide channel support systems, for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
- D. Provide heavy-duty steel trapezes for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
- E. Provide seismic restraint hangers and supports for piping, ductwork and equipment. See Section 23 05 48.
- F. Obtain approval from AHJ for seismic restraint hanger and support system to be installed for piping and equipment. See Section 23 05 48.

**PART 2 - PRODUCTS****2.01 MANUFACTURERS**

- A. Hangers and Supports for HVAC Piping, Ductwork and Equipment:
  - 1. Anvil International
  - 2. B-Line Systems, Incorporated
  - 3. Erico Company, Incorporated
  - 4. Nelson-Olsen Incorporated
  - 5. Rilco Manufacturing Company, Incorporated
  - 6. Snappitz Thermal Pipe Shield Manufacturing
  - 7. Unistrut Corporation
  - 8. Or approved equivalent.
- B. Wall and Floor Sleeves:
  - 1. Thunderline Corporation "Link Seal".
  - 2. Or approved equivalent.
- C. Building Attachments:
  - 1. Anchor-It
  - 2. Gunnebo Fastening Corporation
  - 3. Hilti Corporation
  - 4. ITW Ramset/Red Head
  - 5. Masterset Fastening Systems, Incorporated
  - 6. Or approved equivalent.

**2.02 HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT**

- A. Hanger Rods: Hanger rods continuously threaded or threaded ends only in concealed spaces and threaded ends only in exposed spaces; finish electro-galvanized or cadmium-plated in concealed spaces and prime painted in exposed spaces; sizes per MSS.



- B. Hanger Rod Couplings: Anvil Figure 136, B-Line Figure B3220, or approved equivalent; malleable iron rod coupling with elongated center sight gap for visual inspection; to have same finish as hanger rods.
- C. Channel Hanging System:
  - 1. Framing members No. 12 gauge formed steel channels, 1-5/8-inch square, conforming to ASTM A570 GR33, one side of channel to have a continuous slot within turned lips; framing nut with grooves and spring 1/2-inch size, conforming to ASTM 675 GR60; screws conforming to ASTM A307; fittings conforming to ASTM A575; parts enamel painted or electro-galvanized.
  - 2. Concrete Inserts: Malleable iron body, hot dipped galvanized finish. Lateral adjustment. MSS Type 18.
- D. Continuous Concrete Insert: Steel construction, minimum 12 gauge. Electrogalvanized finish. Pipe clamps and insert nuts to match.
- E. Pipe Hangers:
  - 1. Pipe Rings for Hanger Rods:
    - a. Pipe Sizes 2-inches and Smaller: Adjustable swivel ring hanger, UL listed. Erico 100 or 101, Anvil Figures 69 or 104, or approved equivalent.
    - b. Pipe Sizes 2-1/2-inches and Larger: Clevis type hangers with adjustable nuts on rod, UL listed. Anvil figure 260, Erico 400, or approved equivalent.
    - c. Pipe hangers to have same finish as hanger rods.
- F. Pipe Saddles and Shields:
  - 1. Factory fabricated saddles or shields under piping hangers and supports for insulated piping.
  - 2. Size saddles and shields for exact fit to mate with pipe insulation. 1/2 round, 18 gauge, minimum 12-inches in length (4-inch pipe and larger to be three times longer than pipe diameter).
- G. Riser Clamps: Steel, UL listed. MSS Type 8. Erico 510 or 511. Copper coated; Erico 368.
- H. Pipe Slides: Anvil, reinforced Teflon slide material (3/32-inch minimum thickness) bonded to steel; highly finished steel or stainless steel contact surfaces to resist corrosion; 60-80 PSI maximum active contact surface loading; steel parts 3/16-inch minimum thickness; attachment to pipe and framing by welding.
- I. Pipe Guides:
  - 1. Furnish and install pipe guides on continuous runs where pipe alignment must be maintained. Minimum two on each side of expansion joints, spaced per manufacturer's recommendations for pipe size. Fasten guides securely to pipe and structure. Contact with chilled water pipe not to permit heat to be transferred in sufficient quantity to cause condensation on any surface.
  - 2. Furnish and install guides approximately four pipe diameters (first guide) and 14 diameters (second guide) away from each end of expansion joints. Guides are not to be used as supports and are in addition to other pipe hangers and supports.
- J. Pipe Roller Hangers: Adjustable roller hanger. Black steel yoke, cast iron roller. MSS Type 41.
- K. Below Ground Pipe Supports:
  - 1. Pipe Hangers All Sizes: Adjustable Clevis type, Federal Specification WW-H-171 (Type 1), UL listed, stainless steel Type 304. MSS Type 1. Erico 406.
  - 2. Rod: 5/8-inch stainless steel Type 18-8.
  - 3. Eyebolt: Stainless steel Type 18-8.
  - 4. Nuts and Washers: Stainless steel Type 18-8.
- L. Thermal Hanger Shield Inserts:
  - 1. 100-PSI (690-kPa) minimum compressive strength calcium silicate insulation, encased in sheet metal shield or polyisocyanurate rigid foam exceeding the load bearing weight of the pipe at the hanger point with a PVC vapor barrier.

2. Material for Cold Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with vapor barrier or polyisocyanurate rigid foam with a PVC vapor barrier.
  3. Material for Hot Piping: Water-repellent-treated ASTM C533, Type 1 calcium silicate or polyisocyanurate rigid foam with a PVC vapor barrier.
  4. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.
  5. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of pipe.
  6. Insert Length: Extend 2-inches beyond sheet metal shield for piping operating below ambient air temperature.
  7. Thermal Hanger Shield Insulation Operating Temperature: Meet or exceed fluid temperature in pipe.
- M. Freestanding Roof Supports: Polyethylene high-density UV resistant quick "pipe" block with foam pad.

### **2.03 WALL AND FLOOR SLEEVES**

- A. Below Grade or High Water Table Areas:
1. "Link-Seal" Pipe Sleeves: Neoprene gasket links bolted together around an interior sleeve forming a watertight seal.
  2. Provide Type S unless otherwise noted.
- B. Pre-Engineered Firestop Pipe Penetration Systems: UL listed assemblies for maintaining fire rating of piping penetrations through fire-rated assemblies. Comply with ASTM E814.
- C. Fabricated Accessories:
1. Steel Pipe Sleeves: Fabricate from Schedule 40 black or galvanized steel pipe. Remove end burrs by grinding.
  2. Sheet Metal Pipe Sleeves: Fabricate from G-90 galvanized sheets closed with lock-seam joints. Provide the following minimum gauges for the sizes indicated:
    - a. Sleeve Size 4-inches in Diameter and Smaller: 18 gauge.
    - b. Sleeve Sizes 5-6-inches: 16 gauge.
    - c. Sleeve Sizes 7-inches and Larger: 14 gauge.
    - d. Fire-Rated Safing Material.
      - 1) Rockwool Insulation: Complying with FS-HH-I-558, Form A, Class IV, 6 pounds per cubic foot density with melting point of 1985 degrees F and K value of 0.24 at 75 degrees F.
      - 2) Calcium Silicate Insulation: Noncombustible, complying with FS-HH-I-523, Type II, suitable for 100 degrees F to 1200 degrees F service with K value of 0.40 at 150 degrees F.

### **2.04 BUILDING ATTACHMENTS**

- A. Beam Clamps:
1. MSS Type 19 and 23, wide throat, with retaining clip.
  2. Universal Side Beam Clamp: MSS Type 20.
- B. Powder-Actuated Drive Pin Fasteners: Powder actuated type, drive pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.
- C. Anchor Bolts:
1. Anchor supports to existing masonry, block and tile walls per anchoring system manufacturer's recommendations or as modified by project structural engineer. Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.
  2. Anchor Bolts (Cast-In-Place): Steel bolts, ASTM A307. Nuts to conform to ASTM A194. Design values for shear and tension not more than 80 percent of the allowable listed loads.
  3. Anchor (Expansion) Bolts: Carbon steel to ASTM A307; nut to conform to ASTM A194; drilled-in type. Design values for shear and tension not more than 80 percent of the allowable listed loads.

4. Anchor (Adhesive) Bolts: Consisting of two-part adhesive cartridge and zinc-plated Type A307 steel anchor bolt rod assembly with ASTM A194 nut.

## **2.05 FLASHING**

- A. Steel Flashing: 26 gauge galvanized steel.
- B. Safes: 8 mil thick neoprene.
- C. Caps: Steel, 22 gauge minimum, 16 gauge at fire-resistant structures.

## **2.06 MISCELLANEOUS METAL AND MATERIALS**

- A. General:
  1. Provide miscellaneous metal items specified, including materials, fabrication, fastenings and accessories required for finished installation, where indicated on drawings or otherwise not shown on drawings that are necessary for completion of the project. Contractor is responsible for their design.
  2. Fabricate miscellaneous units to size shapes and profiles indicated or, if not indicated, of required dimensions to receive adjacent other work to be retained by framing. Except as otherwise shown, fabricate from structural steel shapes and plates and steel bars, of welded construction using mitered joints for field connection. Cut, drill and tap units to receive hardware and similar items.
- B. Structural Shapes: Where miscellaneous metal items are needed to be fabricated from structural steel shapes and plates, provide members constructed of steel conforming with requirements of ASTM A36 or approved equivalent.
- C. Steel Pipe: Provide seamless steel pipe conforming to requirements of ASTM A53, Type S, Grade A, or Grade B. Weight and size required as specified.
- D. Fasteners: Provide fasteners of types as required for assembly and installation of fabricated items; surface-applied fasteners are specified elsewhere.
- E. Bolts: Low carbon steel externally and internally threaded fasteners conforming with requirements of ASTM A307; include necessary nuts and plain hardened washers. For structural steel elements supporting mechanical material or equipment from building structural members or connection thereto, use fasteners conforming to ASTM A325.
- F. Miscellaneous Materials: Provide incidental accessory materials, tools, methods, and equipment required for fabrication.
- G. Provide hot dipped galvanized components for items exposed to weather. Use materials compatible with system being supported (i.e. aluminum for aluminum ductwork, stainless steel for stainless steel ductwork).
- H. Use straps, threshold rods and wire with sizes required by SMACNA to support ductwork.
- I. Grout:
  1. ASTM C1107, Grade B, factory mixed and packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.
  2. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
  3. Properties: Nonstaining, noncorrosive, and non gaseous.
  4. Design Mix: 5000-PSI (34.5-MPa), 28-day compressive strength.

## **PART 3 - EXECUTION**

### **3.01 GENERAL INSTALLATION REQUIREMENTS**

- A. Verify building materials to have hangers and attachments affixed in accordance with hangers to be used. Provide supporting calculations.
- B. Examine Drawings and coordinate for verification of exact locations of fire and smoke rated walls, partitions, floors and other assemblies. Indicate, by shading and labeling on Record Drawings such locations and label as "1-Hour Wall", "2-Hour Fire/Smoke Barrier", and the like. Determine proper locations for piping penetrations. Set sleeves in place in new floors, walls or roofs prior to concrete pour or grouting.

- C. Install hangers, supports, anchors and sleeves after required building structural work has been completed in areas where the work is to be installed. Coordinate proper placement of inserts, anchors and other building structural attachments.
- D. Equipment Clearances: Do not route ductwork, equipment, or piping through electrical rooms, transformer vaults, elevator equipment rooms, IT rooms, MPOE rooms, or other electrical or electronic equipment spaces and enclosures and the like. Within equipment rooms, provide minimum 3-foot lateral clearance from all sides of electric switchgear panels. Do not route ductwork, equipment, or piping above any electric power or lighting panel, switchgear, or similar electric device. Coordinate with Electrical and coordinate exact ductwork, equipment or pipe routing to provide proper clearance with such items.

### **3.02 HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT**

- A. Hang rectangular sheet-metal ducts with a cross sectional area of less than 7 SF with galvanized strips of No. 16 USS gauge steel 1-inch wide, and larger ducts with steel angles and adjustable hanger rods similar to piping hangers. Support at a maximum of 8-feet on center.
- B. Support horizontal ducts within 24-inches of each elbow and within 48-inches of each branch intersection.
- C. Provide aluminum supports for aluminum ductwork.
- D. Provide stainless steel supports for stainless steel ductwork.
- E. Support vertical ducts at maximum intervals of 16-feet and at each floor.
- F. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
- G. Use double nuts and lock washers on threaded rod supports.
- H. Floor supports in mechanical rooms to be elevated 1-inch above finish floor and void space filled with masonry grout.
- I. Anchor ducts securely to building in such a manner as to prevent transmission of vibration to structure. Do not connect duct hanger straps to roof deck. Do not support ducts from other ducts, piping or equipment.
- J. Attach strap hangers installed flush with end of sheet-metal duct run to duct with sheet-metal screws.
- K. Construct exterior ductwork or ductwork which is otherwise exposed to weather watertight and slope 1/4-inch per foot to avoid standing water.
- L. Exposed ductwork hung in clean areas such as sanitary areas, pharmaceutical areas, wash down areas or food process areas to be installed using double end, food grade trapeze hanger rods suitable for use with food grade strut.
- M. Channel Support System Installation:
  - 1. Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.
  - 2. Field assemble and install according to manufacturer's written instructions.
- N. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- O. Install hangers and supports to allow controlled thermal and seismic 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.
- P. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- Q. Adjust hangers so as to distribute loads equally on attachments. Provide grout under supports to bring piping, ductwork and equipment to proper level and elevations.
- R. Prime paint ferrous nongalvanized hangers, accessories, and supplementary steel which are not factory painted.

- S. Horizontal Piping Hangers and Supports; Horizontal and Vertical Piping, and Hanger Rod Attachments:
  - 1. Factory fabricated horizontal piping hangers and supports complying with MSS SP-58, to suit piping systems and in accordance with manufacturer's published product information.
  - 2. Use only one type by one manufacturer for each piping service.
  - 3. Select size of hangers and supports to exactly fit pipe size for bare piping, and to exactly fit around piping insulation with saddle or shield for insulated piping.
  - 4. Pipe support spacing (pipe supported in ceiling or floor-supported) to meet latest applicable Code and manufacturer's requirements.
  - 5. Provide copper-plated hangers and supports for uninsulated copper piping systems.
- T. Plumber's Tape not permitted as pipe hangers or pipe straps.
- U. Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure. For horizontally hung grooved-end piping, provide a minimum of 2 hangers per pipe section.
- V. Pipe Ring Diameters:
  - 1. Uninsulated and Insulated Pipe, Except Where Oversized Pipe Rings are Specified: Ring inner diameter to suit pipe outer diameter.
  - 2. Insulated Piping Where Oversized Pipe Rings are Specified and Vibration Isolating Sleeves: Ring inner diameter to suit outer diameter of insulation or sleeve.
- W. Oversize Pipe Rings: Provide oversize pipe rings of 2-inch and larger size.
- X. Pipe Support Brackets: Support pipe with pipe slides.
- Y. Steel Backing in Walls: Provide steel backing in walls to support fixtures and piping hung from steel stud walls.
- Z. Pipe Guides:
  - 1. Install on continuous runs where pipe alignment must be maintained. Minimum two on each side of expansion joints, spaced per manufacturer's recommendations for pipe size. Fasten guides to pipe structure. Contact with chilled water pipe does not permit heat to be transferred in sufficient quantity to cause condensation on any surface.
  - 2. Install approximately four pipe diameters (first guide) and 14 diameters (second guide) away from each end of expansion joints. Do not use as supports. Provide in addition to other required pipe hangers and supports.
- AA. Heavy-Duty Steel Trapeze Installation:
  - 1. Arrange for grouping of parallel runs of horizontal piping and support together on field fabricated, heavy-duty trapezes.
  - 2. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
  - 3. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.
- AB. Group parallel runs of horizontal piping to be supported together on trapeze-type hangers. Maximum spacings: MSS SP-58.
- AC. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe.
- AD. Do not support piping from other piping.
- AE. Fire protection piping will be supported independently of other piping.
- AF. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated.
- AG. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping" is not exceeded.
- AH. Insulated Piping:

1. Attach clamps and spacers to piping.
  - a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
  - b. Piping Operating Below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
2. Do not exceed pipe stress limits according to ASME B31.9.
3. Install MSS SP-58, Type 39 protection saddles, if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
4. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields to span arc of 180 degrees.
5. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN100) and larger if pipe is installed on rollers.
6. Shield Dimensions for Pipe, not less than the following:
  - a. NPS 1/4 to NPS 3-1/2 (DN8 to DN 90): 12-inches long and 0.048-inch thick.
  - b. NPS 4 (DN100): 12-inches long and 0.06-inch thick.
  - c. NPS 5 and NPS 6 (DN125 and DN150): 18-inches long and 0.06-inch thick.
  - d. NPS 8 to NPS 14 (DN200 to DN350): 24-inches long and 0.075-inch thick.
  - e. NPS 16 to NPS 24 (DN400 to DN600): 24-inches long and 0.105-inch thick.
7. Pipes NPS 8 (DN200) and Larger: Include wood Inserts.
  - a. Insert Material: Length at least as long as protective shield.
8. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.
- AI. Pipe Anchors: Provide anchors to fasten piping which is subject to expansion and contraction, and adjacent to equipment to prevent loading high forces onto the equipment.
- AJ. Pipe Curb Assemblies:
  1. Provide prefabricated units for roof membrane and insulation penetrations related to equipment. Coordinate with roofing system. Set supports on the structural deck. Do not set supports on insulation or roofing. Provide level supports by prefabricated pitch built into the curb.
  2. Provide for piping and electrical conduit which penetrates the structural roof deck to service equipment above the roof level (i.e., piping, electrical power and control wiring). Meet requirements of roof warranty.
- AK. Escutcheon Plates: Install around horizontal and vertical piping at visible penetrations through walls, partitions, floors, or ceilings, including penetrations through closets, through below ceiling corridor walls, and through equipment room walls and floors.
- AL. Vertical Piping:
  1. Support with U-clamps fastened to wall to hold piping away from wall unless otherwise approved.
  2. Riser clamps to be directly under fitting or welded to pipe.
    - a. Riser to be supported at each floor of penetration.
    - b. Provide structural steel supports at the base of pipe risers. Size supports to carry forces exerted by piping system when in operation.
- AM. Piping above roof to be supported with freestanding roof pipe supports unless detailed otherwise.

### 3.03 WALL AND FLOOR SLEEVES

- A. "Link-Seal" Pipe Sleeves: Install at floor/below grade piping penetrations. Provide manufacturer's sleeve appropriate to seal type for pre-cast penetrations.
- B. Fabricated Pipe Sleeves:
  1. Provide either steel or sheet metal pipe sleeves accurately centered around pipe routes. Size such that piping and insulation, if any, will have free movement within the sleeve, including allowance for thermal expansion. Sleeve diameter to be determined by local seismic clearance requirements, and by waterproofing requirements.

2. Length: Equal to thickness of construction penetrated, except extend floor sleeves 1-inch above floor finish.
  3. Provide temporary support of sleeves during placement in concrete and other work around sleeves. Provide temporary end closures to prevent concrete and other materials from entering pipe sleeves.
  4. Seal each end airtight with a resilient nonhardening sealer, UL listed, fire rated ASTM 814.
- C. Installation of metallic or plastic piping penetrations through non fire-rated walls and partitions and through smoke-rated walls and partitions:
1. Install fabricated pipe sleeve.
  2. After installation of sleeve and piping, tightly pack entire annular void between piping or piping insulation and sleeve identification with specified material.
  3. Seal each end airtight with a resilient nonhardening UL listed fire resistant ASTM 814.
- D. Piping Penetrations Through Fire-Rated (One to Three Hour) Assemblies:
1. Select and install pre-engineered pipe penetration system in accordance with the UL listing and manufacturer's recommendation.
  2. Provide proper sizing when providing sleeves or core-drilled holes to accommodate the penetration. Firestop voids between sleeve or core-drilled hole and pipe passing through to meet the requirements of ASTM E814.

### **3.04 BUILDING ATTACHMENTS**

- A. Factory fabricated attachments complying with MSS SP-58, selected to suit building substructure conditions and in accordance manufacturer's published product information.
- B. Select size of building attachments to suit hanger rods.
- C. Install concrete inserts before placing concrete.
- D. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
- E. Do not use powder-actuated concrete fasteners for lightweight aggregate concretes or for slabs less than 4-inches thick.
- F. Install within concrete or on structural steel or wood. Attachment to wood structure: Anvil side beam bracket Figure 202 for attachment to wooden beam or approved attachment for a wood structure.
- G. Install additional building attachments where support is required for additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping.
- H. Install concrete inserts before concrete is placed; fasten insert secure to forms. Where concrete with compressive strength less than 2500 PSI is indicated, install reinforcing bars through openings at top in inserts.
- I. Install building attachments within concrete slabs or attach to structural steel. Space attachments within maximum piping span length indicated in MSS SP-58. Install additional attachments at concentrated loads, including valves, flanges guides, strainers, and expansion joints, 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.
- J. Install powder-actuated drive-pin fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
- K. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- L. Bolting: Provide bored, drilled or reamed holes for bolting to miscellaneous structural metals, frames or for mounts or supports. Flame cut, punched or hand sawn holes will not be accepted.
- M. Anchor Bolts:

1. Install anchor bolts for mechanical equipment, piping and ductwork as required. Tightly fit and clamp base-supported equipment anchor bolts at equipment support points. Provide locknuts where equipment, piping and ductwork are hung.
2. Anchor bolts (Cast-In-Place): Embed anchor bolts in new cast-in-place concrete to anchor equipment. Install a pipe sleeve around the anchor bolt for adjustment of the top 1/3 of the bolt embedment; sizes and patterns to suit the installation conditions of the equipment to be anchored.

N. Testing: Test powder-actuated insert attachments with a minimum load of 100 pounds.

### **3.05 FLASHING**

- A. Flash and counterflash where piping, ductwork and equipment passes through weather or waterproofed walls, floors, and roofs.
- B. Provide 12-inches minimum height curbs for roof-mounted mechanical equipment. Flash and counter flash with galvanized steel, soldered and waterproofed.

### **3.06 MISCELLANEOUS METAL AND MATERIALS**

- A. General: Verify dimensions prior to fabrication. Form metal items to accurate sizes and configurations as indicated on drawings and otherwise required for proper installation; make with lines straight and angles sharp, clean and true; drill, countersink, tap, and otherwise prepare items for connections with work of other trades, as required. Fabricate to detail of structural shapes, plates and bars; weld joints where practicable; provide bolts and other connection devices required. Include anchorages; clip angles, sleeves, anchor plates, and similar devices. Hot dipped galvanize after fabrication items installed in exterior locations. Set accurately in position as required and anchor securely to building construction. Construct items with joints formed for strength and rigidity, accurately machining for proper fit; where exposed to weather, form to exclude water.
- B. Finishes:
  1. Ferrous Metal: After fabrication, but before erection, clean surfaces by mechanical or chemical methods to remove rust, scale, oil, corrosion, or other substances detrimental to bonding of subsequently applied protective coatings. For metal items exposed to weather or moisture, galvanize in manner to obtain G90 zinc coating in accordance with ASTM A123. Provide other non-galvanized ferrous metal with 1 coat of approved rust-resisting paint primer, in manner to obtain not less than 1.0 mil dry film thickness. Touch-up damaged areas in primer with same material, before installation. Apply zinc coatings and paint primers uniformly and smoothly; leave ready for finish painting as specified elsewhere.
  2. Metal in Contact with Concrete, Masonry and Other Dissimilar Materials: Where metal items are to be erected in contact with dissimilar materials, provide contact surfaces with coating of an approved zinc-chromate primer in manner to obtain not less than 1.0 mil dry film thickness, in addition to other coatings specified in these specifications.
  3. For Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and apply galvanizing repair paint to comply with ASTM A780.
- C. Coordinate and furnish anchorages, setting drawings, diagrams, templates, instructions, and directions for installation of anchorages, such as concrete inserts, sleeves, anchor bolts and miscellaneous items having integral anchors, which are to be embedded in concrete or masonry construction. Coordinate delivery of such items to project site.
- D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing miscellaneous metal fabrications to in-place construction; including, threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, lag bolts, wood screws and other connectors as required. Avoid cutting concrete reinforcing when drilling for inserts. Reference structural drawings and reinforcing shop drawings and determine locations of stirrups prior to drilling into concrete.
- E. Cutting, Fitting and Placement: Perform cutting, drilling and fitting required for installation of miscellaneous metal fabrications. Set work accurately in location, alignment and elevation, plumb, level, true and free of rack, measured from established lines and levels. Provide



temporary bracing or anchors in formwork for items, which are to be built into concrete masonry or similar construction.

- F. **Field Welding:** Comply with AWS Code for procedures of manual shielded metal-arc welding, appearance and quality of welds made, and methods used in correcting welding work.
- G. **Setting Loose Plates:** Clean concrete and masonry bearing surfaces of any bond reducing materials, and roughen to improve bond to surfaces. Clean bottom surface of bearing plates.
- H. Set loose leveling and bearing plates on wedges, or other adjustable devices. After the bearing members have been positioned and plumbed, tighten the anchor bolts. Do not remove wedges or shims, but if protruding, cut-off flush with edge of the bearing plate before packing with grout. Use metallic non-shrink grout in concealed locations where not exposed to moisture; use non-metallic non-shrink grout in exposed locations, unless otherwise indicated.
- I. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.
- J. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.
- K. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.
- L. **Field Welding:** Comply with AWS D1.1 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 contours of welded surfaces match adjacent contours.
- M. Provide galvanized components for items exposed to weather.

**END OF SECTION**



**SECTION 23 05 48****VIBRATION AND SEISMIC CONTROLS FOR HVAC EQUIPMENT****PART 1 - GENERAL****1.01 SUMMARY**

- A. Work Included:
  - 1. Vibration Isolation
  - 2. Seismic Restraint Devices
  - 3. Factory Finishes
  - 4. Seismic-Bracing/Restraint Devices/Systems for Equipment, Piping and Ductwork
- B. General:
  - 1. Vibration isolation for mechanical ductwork, piping and equipment.
  - 2. Seismic restraint for mechanical ductwork, piping and equipment.
  - 3. Seismic Certification for equipment, hangers and systems
  - 4. Special inspections for systems.
- C. Scope of Work:
  - 1. Vibration isolation and seismic restraint of new equipment and systems within project boundary defined in architectural drawings.
  - 2. Vibration isolation and seismic restraint of new equipment and systems in existing buildings to points of connection with existing systems.
  - 3. Seismic restraint of existing systems and equipment shown on drawings, within project boundary defined in architectural drawings.
  - 4. Provide supplementary structural steel for seismic restraint systems. No hanging from roof deck is permitted on this project, unless specifically allowed by Structural Engineer of Record in writing prior to bid.

**1.02 RELATED SECTIONS**

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

**1.03 REFERENCES AND STANDARDS**

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

**1.04 SUBMITTALS**

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
  - 1. Vibration Isolation:
    - a. Product Data: Provide catalog data indicating size, type, load and deflection of each isolator; and percent of vibration transmitted based on lowest disturbing frequency of equipment.
    - b. Shop Drawings: Showing complete details of construction for steel and concrete bases including:
      - 1) Fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment and cantilever loads.
      - 2) Equipment mounting holes.
      - 3) Dimensions.
      - 4) Size and location of concrete and steel bases and curbs.
      - 5) Isolation selected for each support point.
      - 6) Details of mounting brackets for isolator.
      - 7) Weight distribution for each isolator.
      - 8) Details of seismic snubbers.
      - 9) Code number assigned to each isolator.

- c. Design calculations: Provide calculations for selecting vibration isolators and for designing vibration isolation bases.
2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
3. Seismic Restraint:
  - a. Shop Drawings: Show compliance with requirements of Quality Assurance article of this Section. Shop drawings to be stamped by a professional Structural Engineer licensed in State of Oregon.
  - b. Calculations: Submit seismic calculations indicating restraint loadings resulting from design seismic forces. Include anchorage details and indicate quantity, diameter and depth of penetration of anchors. Calculations certified by professional Structural Engineer licensed in State of Oregon.
4. Seismic Restraint Details: Detail fabrication and attachment of seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter and depth of penetration of anchors.
5. Submittals for Interlocking Snubbers: Include load deflection curves up to 1/2-inch deflection in x, y and z planes.
6. Welding certificates.
7. Equipment Certification: Provide seismic certification for equipment as noted in Seismic Design Summary or schedules on Drawings.

#### **1.05 QUALITY ASSURANCE**

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
  1. Vibration Isolation:
    - a. Except for packaged equipment with integral isolators, single manufacturer selects and furnishes isolation required.
    - b. Deflections indicated on drawings are minimum actual static deflections for specific equipment supported.
    - c. Isolator Stability:
      - 1) Size springs of sufficient diameter to maintain stability of equipment being supported. Spring diameters not less than 0.8 of compressed height at rated load.
      - 2) Springs have minimum additional travel to solid equal to 50 percent of rated deflection.
      - 3) Springs support 200 percent of rated load, fully compressed, without deformation or failure.
    - d. Maximum Allowable Vibration Levels: Peak vibration velocities not exceed 0.08 in/sec. Correct equipment operating at vibration velocities that exceed this criteria.
  2. Seismic Restraint:
    - a. Code and Standard Requirements:
      - 1) Seismic restraint of equipment, piping and ductwork to be in accordance with latest enacted version of ASCE 7-10.
    - b. Confirm Seismic Control requirements in Division 01, General Requirements and Structural documents.
    - c. Certification: See Seismic Design Table or schedules on Drawings for equipment, systems and seismic-restraint devices designated to have seismic certification/qualification. Horizontal and vertical load testing and analysis performed according to ASCE 7-10. Anchorage systems to bear anchorage preapproval number from an agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing or calculations, if preapproved ratings are not available. Calculations (including combining shear and

tensile loads) to support seismic-restraint designs must be sealed by qualified licensed professional engineer in State of Oregon. Testing and calculations must include both shear and tensile loads and one test or analysis at 45 degrees to weakest mode.

- d. Seismic restraint and anchorage of permanent equipment and associated systems listed below to building structure be designed to resist total design seismic force prescribed in local building code:
  - 1) Floor- or roof-mounted equipment weighing 400 pounds or greater.
  - 2) Suspended, wall-mounted or vibration isolated equipment weighing 20 pounds or greater.
  - 3) In-line duct devices connected to ductwork weighing 75 pounds or greater.
  - 4) Housekeeping slabs: provide reinforcement and anchorage to building structure.
- e. Where required, seismic sway bracing of suspended duct and piping meet following:
  - 1) Pipe and duct runs requiring seismic bracing have minimum of two traverse braces and one longitudinal brace. Longitudinal (or traverse) brace at 90 degree change in direction may act as traverse (or longitudinal) brace if located within 2-feet of change in direction.
  - 2) Seismic bracing may not pass through seismic separation joint. Pipe or duct runs that pass through seismic separation joint must be restrained within 5-feet of both sides of separation.
  - 3) Seismic brace assembly spacing not to exceed 40-feet transverse and 80-feet longitudinal.
- f. Seismic restraints may be omitted from suspended piping and duct if following conditions are satisfied:
  - 1) For piping or ducts supported by rod hangers 12-inches or less in length from top of duct to bottom of structural support. Top connections to structure have swivel joints, eye bolts, or vibration isolation hangers for entire length of system run.
  - 2) Lateral motion of system will not cause damaging impact with surrounding systems or cause loss of system vertical support.
  - 3) System must be welded steel pipe, brazed copper pipe, sheet metal duct or similar ductile material with ductile connections.
- C. Seismic restraints, including anchors to building structure, be designed by registered professional Structural Engineer licensed in State of Oregon. Design includes:
  - 1. Number, size, capacity and location of anchors for floor- or roof-mounted equipment. For curb-mounted equipment, provide design of attachment of both unit to curb and curb to structure.
  - 2. Number, size, capacity and location of seismic restraint devices and anchors for vibration-isolation and suspended equipment. Provide calculations and test data verifying horizontal and vertical ratings of seismic restraint devices.
  - 3. Number, size, capacity and location of braces and anchors for suspended piping and ductwork on as-built plan drawings.
  - 4. Maximum seismic loads to be indicated on drawings at each brace location. Drawings bear stamp and signature of registered professional Structural Engineer who designed layout of braces.

#### **1.06 WARRANTY**

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

#### **1.07 EXTRA MATERIALS**

- 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.
- B. Seismic Snubber Units: Furnish replacement neoprene inserts for snubbers.

**PART 2 - PRODUCTS****2.01 MANUFACTURERS**

- A. Vibration Isolation:
  - 1. The VMC Group
  - 2. B-Line Systems, Inc.
  - 3. Kinetics Noise Control, Inc.
  - 4. Mason Industries Inc.
  - 5. M.W. Sausse - Vibrex
  - 6. Where Mason numbers are specified, equivalent products by listed manufacturers are acceptable.
  - 7. Or approved equivalent.
- B. Seismic Restraint Devices:
  - 1. The VMC Group
  - 2. B-Line Systems, Inc.
  - 3. Hilti, Inc.
  - 4. Kinetics Noise Control, Inc.
  - 5. Mason Industries, Inc.
  - 6. California Dynamics Corporation
  - 7. Cooper B-Line Tolco.
  - 8. Unistrut Diversified Products Co.; Wayne Manufacturing Division.
  - 9. M.W. Sausse - Vibrex
  - 10. Or approved equivalent.
- C. Factory Finishes:
  - 1. Kynar 500 Fluoropolymer Coating
  - 2. Or approved equivalent.
- D. Seismic-Bracing/Restraint Devices/Systems for Equipment, Piping and Ductwork:
  - 1. The VMC Group
  - 2. California Dynamics Corporation
  - 3. Cooper B-Line, Inc.
  - 4. Hilti, Inc.
  - 5. Mason Industries, Inc.
  - 6. Kinetics Noise Control.
  - 7. Unistrut
  - 8. ISAT, Inc.
  - 9. Where Mason numbers are specified, equivalent products by listed manufacturers are acceptable.
  - 10. Or approved equivalent.

**2.02 VIBRATION ISOLATION**

- A. Type 1 - Neoprene Pad: Natural rubber waffle pads, arranged in single or multiple layers, 3/4-inch thick per layer with pattern repeating on 1/2-inch centers; 50 durometer hardness; maximum loading 60 PSI. 1/4-inch thick steel load distribution plate between layers and between pad and equipment, factory cut to sizes matching requirements of supported equipment. Molded bridge with neoprene anchor bolt bushing and flat washer face to prevent metal to metal contact. Number of layers required for equipment scheduled. Mason Type: Super WMH.
- B. Type 2 - Neoprene Mount: Double-deflection type, with ductile-iron housing containing two separate and opposing, oil-resistant natural rubber or bridge bearing neoprene elements, factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Neoprene elements to prevent metal to metal contact during normal operation. Minimum static deflection of 0.20-inches. Mason Type: BR.
- C. Type 3 - Spring: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of compressed height of spring at rated load.
  2. Minimum Additional Travel: 50 percent of required deflection at rated load.
  3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, natural rubber or bridge bearing neoprene isolator pad attached to baseplate underside. Baseplates limit floor load to 100 PSIG (690 kPa).
  6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
  7. Brackets: Manufacturer's standard bracket, utilize height saving brackets to accommodate height restrictions.
  8. Mason Type: SLFH.
- D. Type 4a - Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
1. Housing: Steel with resilient vertical-limit stops (out of contact during normal operation) to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch thick, natural rubber or bridge bearing neoprene isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation. Restraining bolts have large rubber grommets to provide cushioning in vertical and horizontal directions. A minimum clearance of 3/8-inch maintained around restraining bolts so as not to interfere with spring action.
  2. Outside Spring Diameter: Not less than 80 percent of compressed height of spring at rated load.
  3. Minimum Additional Travel: 50 percent of 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. Brackets: Manufacturer's standard bracket, utilize height saving brackets to accommodate height restrictions.
  7. Mason Type: SLR.
- E. Type 4b - Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.
1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint with neoprene acoustical cup, spring inspection ports and rebound adjustment ports.
  2. Base: Factory drilled for bolting to structure.
  3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch travel before contacting a resilient collar.
  4. Brackets: Manufacturer's standard bracket, utilize height saving brackets to accommodate height restrictions.
  5. Mason Type: SSLFH.
- F. Type 5a - Restrained Elastomeric Hangers: Double-deflection type, with molded, oil-resistant natural rubber or bridge bearing neoprene isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range. Seismic rebound steel and bonded LDS rubber washer to limit upward seismic movement. Mason Type: RWHD.
- G. Type 5b- Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 15 degrees of angular hanger-rod misalignment from vertical without binding or reducing isolation efficiency.
  2. Outside Spring Diameter: Not less than 80 percent of compressed height of spring at rated load.
  3. Minimum Additional Travel: 50 percent of 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. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
  7. Mason Type: 30N.
- H. Type FC-1, Flexible duct connectors. See Specification Section 23 33 00 Air Duct Accessories.
- I. Type FC-2A, Flexible Pipe Connector, Steel:
1. 321 stainless steel, close pitch, annular corrugated hose.
  2. Exterior Sleeve: 304 stainless steel, braided.
  3. Pressure Rating: 125 PSI at 70 degrees F for 12-inch and smaller pipe.
  4. Joint: ANSI Class 150 carbon steel flanges.
  5. Size: Use pipe sized units.
  6. Minimum Allowable Offset: 3/4-inch on each side of installed center line.
  7. Basis of Design: Metraflex Model MLP.
- J. Type FC-2B, Flexible Pipe Connector, Copper:
1. Inner Hose: Bronze, close pitch, annular corrugated hose.
  2. Exterior Sleeve: Braided bronze (for piping over 2-inches, to be 3 pound braided stainless steel).
  3. Minimum Allowable Pressure Rating: 125 PSI at 70 degrees F.
  4. Joint: Sweat ends.
  5. Size: Use pipe sized units.
  6. Minimum Allowable Offset: 3/8-inch on each side of installed center line.
  7. Basis of Design: Metraflex Model BBS.
- K. Type FC-2C, Flexible Pipe Connector, Gas:
1. Inner Hose: 304 stainless steel.
  2. Exterior Sleeve: Braided, 304 stainless steel.
  3. Minimum Allowable Pressure Rating: 150 PSI at 70 degrees F up to 4-inch pipe.
  4. Joint: Threaded carbon steel.
  5. Minimum Allowable Offset: 3/4-inch on each side of installed center line.
  6. Basis of Design: Metraflex GASCT.
- L. Type FC-3, Flexible Compensator, Double Sphere:
1. Body: Molded twin spherical type. Neoprene with internal cord or wire.
  2. Minimum Pressure Rating, Sizes 2-inch to 12-inch: 225 PSI at 170 degrees F.
  3. Minimum Pressure Rating, Sizes 14-inch to 20-inch: 125 PSI at 170 degrees F.
  4. Minimum Allowable Compression: 1-1/2 inches.
  5. Minimum Allowable Elongation: 1-1/8 inches.
  6. Minimum Allowable Offset: 1-1/8 inches.
  7. Minimum Allowable Angular Movement: 20 degrees.
  8. Joint: Steel flanges.
  9. Accessories: Galvanized aircraft-type cable or control rods to prevent over extension.
  10. Basis of Design: Metraflex Doublesphere.

## 2.03 SEISMIC RESTRAINT DEVICES

- A. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251 and having a durometer of 50, plus or minus 5, with a flat washer face.
- B. Seismic Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts and replaceable resilient isolation washers and bushings. Snubber load rating to match equipment size. Mason Type: Z-1011 or Z-1225.
1. Anchor bolts for attaching to concrete be seismic-rated, drill-in and stud-wedge or female-wedge type.
  2. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251 and having a durometer of 50, plus or minus 5.



- C. Restraining Cables: Galvanized steel aircraft cables with end connections made of steel assemblies that swivel to final installation angle and utilize two clamping bolts for cable engagement. Mason Type: SCB.
- D. Anchor Bolts: Seismic-rated, drill-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488/E 488M.

## **2.04 FACTORY FINISHES**

- A. Provide manufacturer's standard prime-coat finish ready for field painting. Units mounted outdoors exposed to weather: Epoxy powder coated, with 1000 hour salt spray rating per ASTM B-117. For high levels of corrosion protection utilize:
  - 1. Conform to AAMA 605.2.
  - 2. Apply coating following cleaning and pretreatment.
  - 3. Cleaning: AA-C12C42R1X.
  - 4. Dry system before final finish application.
  - 5. Total Dry Film Thickness: Approximately 1.2 mils, when baked at 450 degrees F for 10 minutes.

## **2.05 SEISMIC-BRACING/RESTRAINT DEVICES/SYSTEMS FOR EQUIPMENT, PIPING AND DUCTWORK**

- A. General Requirements for Restraint Components: Rated strengths, features and applications to be as defined in reports by agency acceptable to authorities having jurisdiction.
- B. Structural Safety Factor: Allowable strength in tension, shear and pullout force of components be at least four times maximum seismic forces to which they will be subjected.
- C. Anchor bolts for attaching to concrete to be seismic-rated, drill-in and stud-wedge or female-wedge type.
- D. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
- E. Maximum 1/4-inch air gap and minimum 1/4-inch thick resilient cushion.

## **PART 3 - EXECUTION**

### **3.01 GENERAL INSTALLATION REQUIREMENTS**

- A. Provide mounts for equipment installed outdoors for wind loads of 30 lbs. psf applied to any exposed surface of isolated equipment.
- B. Do not install equipment or pipe which makes rigid contact with building slabs, beams, studs, walls, etc.
- C. Anchor baseplate to floor or structure. Provide rubber grommets and washers to isolate bolt from base plate. Under no circumstances is isolation efficiency to be destroyed when bolting isolators to floor.
- D. Building Penetrations: Isolate water piping and ductwork penetrating wall, ceilings, floors or shafts from structure by piping isolator or by 3/8-inch thick foamed rubber insulation. Install units flush with finished structure face, using one for each side as required. Cut units to length if longer than structure thickness. Caulk around pipe or duct at equipment room wall.
- E. Provide roof curbs, equipment supports and roof penetrations. Work to maintain roof warranty. Coordinate location, size, structural connections/requirements and flashing prior to installation.
- F. Install Type 6 horizontal thrust restraints at centerline of thrust, symmetrical on either side of equipment.
- G. Vibration isolators must not cause change of position of equipment or piping which would stress piping connections or misalignment shafts or bearings. Isolated equipment is to be level and in proper alignment with connecting ducts and pipes.
- H. Pipe Hangers in Equipment Rooms: Support water and gas piping connected to rotating equipment within equipment rooms on spring and neoprene hangers. The first three hangers from a piece of vibrating equipment are to have a minimum of 1/2 static deflection of equipment isolators. Other isolators should have a minimum of 1/4 static deflection of equipment isolators.

- I. Examination:
  - 1. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements, installation tolerances and other conditions affecting performance.
  - 2. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
  - 3. Proceed with installation only after unsatisfactory conditions have been corrected.
- J. Testing: Perform following field quality-control testing:
  - 1. Isolator seismic-restraint clearance.
  - 2. Isolator deflection.
  - 3. Snubber minimum clearances.
- K. Adjusting:
  - 1. Adjust snubbers according to manufacturer's written recommendations.
  - 2. Torque anchor bolts according to equipment manufacturer's written recommendations to resist seismic forces.
- L. Cleaning: After completing equipment installation, inspect vibration isolation and seismic-control devices. Remove paint splatters and other spots, dirt and debris.
- M. Demonstration: Engage factory-authorized service representative to train Owner's maintenance personnel to adjust, operate and maintain air-mounting systems. Reference Division 01, General Requirements.

### 3.02 VIBRATION ISOLATION

- A. Reference 3.01, General Installation Requirements.
- B. Install per manufacturer's instructions and recommendations.
- C. Vibration isolators must be installed in strict accordance with manufacturer's written instructions and certified submittal data.
- D. Install isolation as indicated on drawings by type and location and where indicated below.
- E. Equipment Vibration Isolation Schedule:

Equipment	Size	Vibration Isolator Type	Minimum Deflection (in)
Fan-coils	All	Type 5B, FC-1,2	0.75
Condensing Units	0 to 4.5 tons	Type 1 or 2	0.2
Condensing Units	5+ tons	Type 4A	2.5
Axial, Cabinet, Centrifugal Inline Fans	0 to 23.5-inch diameter	Type 3, 4A, 4B, 5B, FC-1	0.75
Axial, Cabinet, Centrifugal Inline Fans	24-inch+ diameter	Type 3, 4A, 4B, 5B, FC-1	1.5

- F. Isolation Mounts:
  - 1. Install minimum of four seismic snubbers on isolated equipment. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
  - 2. Install resilient bolt isolation washers on equipment anchor bolts.
  - 3. Provide flexible piping connection and flexible ductwork connection to equipment with isolation mounts or bases.
- G. Isolating Hangers:
  - 1. Support piping and ductwork connected to isolated equipment within equipment rooms on isolating hangers as scheduled on drawings. Unless otherwise noted, first three hangers

- from isolated equipment to have a minimum of 1/2 static deflection of equipment isolators. Other isolating hangers to have a minimum of 1/4 static deflection of equipment isolators.
2. Position isolating hanger elements as high as possible in hanger rod assembly, but not in contact with building structure. Install hangers so that hanger housing may rotate full 360 degrees about rod axis without contacting any object.
  3. Unless otherwise noted, air supply units with internally isolated fans do not require isolating hangers for connecting pipes and ductwork.
  4. Where parallel running pipes are hung together on an isolated trapeze, provide isolator deflections for largest determined by provisions for pipe isolation. Do not mix isolated and non-isolated pipes in same trapeze.
  5. Install limit stops so they are out of contact during normal operation.
- H. Adjusting:
1. Adjust isolators after piping systems have been filled and equipment is at operating weight.
  2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
  3. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop.

### **3.03 SEISMIC RESTRAINT DEVICES**

- A. Reference 3.01, General Installation Requirements.
- B. Install in strict accordance with manufacturer's written instructions and certified submittal data.
- C. Install and adjust seismic restraints so equipment, piping and ductwork supports are not degraded by restraints.
- D. Restraints must not short circuit vibration isolation systems or transmit objectionable vibration or noise.
- E. Install restraining cables at each trapeze, individual pipe hanger and hanging vibration isolated equipment. Provide restraining cables in each of the four directions of movement. Install restraining cables no less than 45 Degrees from vertical. At trapeze anchor locations, shackle piping to trapeze. Install cables so they do not bend across sharp edges of adjacent equipment or building structure.
- F. Install steel angles or channel, sized to prevent buckling, clamped with ductile-iron clamps to hanger rods for trapeze and individual pipe hangers. At trapeze anchor locations, shackle piping to trapeze. Requirements apply equally to hanging equipment. Do not weld angles to rods.

### **3.04 FACTORY FINISHES**

- A. Reference 3.01, General Installation Requirements.
- B. Install per manufacturer's instructions and recommendations.
- C. Finishes to be factory-applied. No field patching or holidays allowed.

### **3.05 SEISMIC-BRACING/RESTRAINT DEVICES/SYSTEMS FOR EQUIPMENT, PIPING AND DUCTWORK**

- A. Reference 3.01, General Installation Requirements.
- B. Install per manufacturer's instructions and recommendations.
- C. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

**END OF SECTION**



**SECTION 23 05 53****IDENTIFICATION FOR HVAC PIPING, DUCTWORK AND EQUIPMENT****PART 1 - GENERAL****1.01 SUMMARY**

- A. Work Included:
  - 1. Plastic Nameplates
  - 2. Tags
  - 3. Ceiling Tags

**1.02 RELATED SECTIONS**

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

**1.03 REFERENCES AND STANDARDS**

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

**1.04 SUBMITTALS**

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
  - 1. Schedules:
    - a. Submit valve schedule for each piping system, in tabular format using Microsoft Word or Excel software. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), and variations for identification (if any). Mark valves which are intended for emergency shutoff and similar special uses by special "flags" in margin of schedule. In addition to mounted copies, furnish extra copies for maintenance manuals.

**1.05 QUALITY ASSURANCE**

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
  - 1. Manufacturer's Qualifications: Firms regularly engaged in manufacture of identification devices of types and sizes required.
  - 2. Codes and Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices unless otherwise indicated.

**1.06 WARRANTY**

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

**PART 2 - PRODUCTS****2.01 MANUFACTURERS**

- A. General: Manufacturer's standard products of categories and types required for each application as referenced in other Division 23, HVAC Sections. Where more than a single type is specified for application, provide single selection for each product category.
- B. Plastic Nameplates:
  - 1. Brady Corporation
  - 2. Brimar
  - 3. Champion America
  - 4. Craftmark
  - 5. Seton
  - 6. Or approved equivalent.
- C. Tags:

1. Brady Corporation
  2. Brimar
  3. Champion America
  4. Craftmark
  5. Seton
  6. Or approved equivalent.
- D. Ceiling Tags:
1. Brady Corporation
  2. Brimar
  3. Champion America
  4. Craftmark
  5. Seton
  6. Or approved equivalent.

## **2.02 PLASTIC NAMEPLATES**

- A. Description: Engraving stock melamine plastic laminate in the size and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, black with white core (letter color), punched for mechanical fastening except where adhesive mounting is necessary because of substrate. Provide 1/8-inch thick material.
1. Letter Color: White.
  2. Letter Height: 1/2-inch.
  3. Background Color: Black.
  4. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.
  5. Access Panel Markers: Manufacturer's standard 1/16-inch thick engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve or devices/equipment. Include center hole to allow attachment.

## **2.03 TAGS**

- A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 2-inch diameter.
- B. Metal Tags: Polished Brass with stamped letters; tag size minimum 2-inch diameter with smooth edges.
- C. Valve designations to be coordinated with existing valve identifications to ensure no repetitive designations are utilized.
- D. Chart/Schedules: Valve Schedule Frames. For each page of a valve schedule, provide glazed display frame with removable mounting as appropriate for wall construction upon which frame is to be mounted. Provide frames of finished hardwood or extruded aluminum, with SSB-grade sheet glass.
- E. Valve Tag Fasteners: Solid brass chain (wire link or beaded type), or solid brass S-hooks.
- F. Warning Tags: Preprinted or partially preprinted, accident-prevention tags; of plasticized card stock with matte finish suitable for writing.
1. Size: Approximately 4 by 7-inches.
  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.

## **2.04 CEILING TAGS**

- A. Description: Steel with 3/4-inch diameter color coded head.
- B. Color code as follows:
1. Yellow - HVAC equipment.
  2. Red - Fire dampers/smoke dampers.
  3. Blue - Heating/cooling valves.

4. Ceiling tile labels, machine generated, adhesive backed tape labels with black letters, clear tape.

### **PART 3 - EXECUTION**

#### **3.01 GENERAL - INSTALLATION**

- A. Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates riveted to equipment body.
- B. Identify ductwork with plastic ductmarkers.
- C. Identify piping, concealed or exposed, with plastic pipe markers.
- D. Coordinate names, abbreviations and other designations used in mechanical identification work with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of mechanical systems and equipment.
- E. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as well as service (as examples: Chiller No. 3, Air Handling Unit No. 42, Standpipe F12, and the like).
- F. Degrease and clean surfaces to receive adhesive for identification materials.
- G. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.
- H. Coordinate with the facility maintenance personnel to ensure consistency with the existing tagging system.
- I. Install all products in accordance with manufacturer's instructions.
- J. Manual Balancing Dampers: Provide 12-inch long orange marker ribbon to end of balancing damper handle.

#### **3.02 PLASTIC NAMEPLATES**

- A. Install plastic nameplates with corrosive-resistant mechanical fasteners.
- B. Identify control panels and major control components outside panels with plastic nameplates riveted to equipment body.
- C. Identify thermostats with nameplates.

#### **3.03 TAGS**

- A. Use metal tags on piping 3/4-inch diameter and smaller.
- B. Tag balancing valves and major dampers with balanced GPM or CFM indicated after balancing is completed and accepted.
- C. Install tags with corrosion resistant chain.
- D. Small devices, such as in-line pumps, may be identified with tags.
- E. Identify valves in main and branch piping with metal tags. Indicate valve function and the normally open or closed positions on the valve tag.
- F. Identify air terminal units and radiator valves with numbered plastic tags.
- G. Tag automatic controls, instruments, and relays. Key to control schematic.
- H. Install valve schedule at each mechanical room.

#### **3.04 CEILING TAGS**

- A. Provide ceiling tile labels to identify valves, dampers, and equipment above accessible ceilings.

- B. Provide ceiling tags to locate valves, dampers, and equipment above accessible ceilings.  
Locate in corner of ceiling tee grid closest to equipment.

**END OF SECTION**



**SECTION 23 05 93**  
**TESTING, ADJUSTING, AND BALANCING FOR HVAC**

**PART 1 - GENERAL****1.01 SUMMARY**

- A. Work Included:
  - 1. General Requirements and Procedures
  - 2. Fundamental Air Systems Balancing Procedures
  - 3. Temperature Control Verification
  - 4. Constant Volume Air Systems Balancing Procedures
  - 5. Pre-Balance Reporting
  - 6. Final Reports:
    - a. Report Requirements
    - b. General Report Data
    - c. System Diagrams
    - d. Refrigerant Coils
    - e. Fans
    - f. Duct Traverses
    - g. Diffusers/Registers/Grilles
    - h. Compressor and Condensers
    - i. Instrument Calibration
  - 7. Additional Tests

**1.02 RELATED SECTIONS**

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

**1.03 REFERENCES AND STANDARDS**

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

**1.04 SUBMITTALS**

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
  - 1. Quality-Assurance Submittals: Submit two copies of evidence that the Testing, Adjusting, and Balancing (TAB) Agent and this Project's TAB team members meet the qualifications specified in the "Quality Assurance" Article below.
  - 2. Pre-Construction Phase Report:
    - a. Provide a pre-construction phase TAB Plan at least two weeks prior to the commencement of TAB work. This report is to include:
      - 1) A complete set of report forms intended for use on the project, with data filled in except for the field readings. Forms to be Project-specific.
      - 2) Marked up shop drawings identifying all HVAC equipment to be balanced, and associated outlets and terminal devices.
      - 3) Identification of the type, manufacturer, and model of the actual instruments to be used, and clear indication of which instrument will be used to take each type of reading. Calibration certifications are to be included.
      - 4) A narrative of any project specific and/or non-standard TAB procedures to be used, and the equipment or systems they apply to.
  - 3. Contract Documents Examination Report: Within 45 days from the Contractor's Notice to Proceed, submit two copies of the Contract Documents review report as specified in Part 3 of this Section.
  - 4. Strategies and Procedures Plan: Submit two copies of the TAB strategies and step-by-step procedures as specified in Part 3 below. Include a complete set of report forms intended for use on this Project.

5. Specify reports required because of editing procedures in Part 3 of this Section.
6. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by the TAB Agent.
7. Sample Report Forms: Submit two sets of sample TAB report forms.
8. Test Instrument Calibration: Submit proof of calibration within the last 6 months.
9. Final Report.
10. Provide additional submittals to commissioning authority as dictated in commissioning specifications.

#### **1.05 QUALITY ASSURANCE**

- A. Quality Assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
  1. Acceptable Manufacturers:
    - a. Oregon:
      - 1) Air Introduction and Regulations Inc.
      - 2) Accurate Air Balance, Inc.
      - 3) Neudorfer Engineers
      - 4) Northwest Engineering Services
      - 5) Pacific Coast Air Balance
      - 6) Testcomm
  2. Acceptable Balance Firm:
    - a. General:
      - 1) Procure services of independent TAB agency to balance, adjust and test water circulating and air moving equipment and air distribution or exhaust systems. Minimum experience: 5 years.
    - b. Industry Standards: Testing and Balancing will conform to NEBB, American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE), and American National Standards Institute (ANSI) as follows:
      - 1) NEBB: Comply with Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
      - 2) ASHRAE: Comply with recommendations pertaining to measurements, instruments, and TAB.
      - 3) ANSI:
        - (a) S1.4 Specifications for sound level meters.
        - (b) S1.11 Specifications for Octave-Band and Fractional-Octave-Band analog and digital filters.
        - (c) ANSI S1.13 Methods for the Measurement of Sound Pressure Levels.
    - c. Test Observation: If requested, conduct tests in the presence of the Architect or the Architect's representative.
  3. Provide proof of testing agency having successfully completed at least five projects of similar size and scope.
  4. Code Compliance: Perform tests in the presence of the Authority Having Jurisdiction (AHJ) where required by the Authority Having Jurisdiction (AHJ).
  5. Owner Witness: Perform tests in the presence of the Owners representative.
  6. Engineer Witness: The engineer or engineer's representative reserves the right to observe tests or selected tests to assure compliance with the specifications.
  7. Simultaneous Testing: Test observations by the AHJ, the Owner's representative and the engineer's representative need not occur simultaneously.
  8. Do not perform TAB work until heating, ventilating, and air conditioning equipment has been completely installed and is operating continuously as required.
  9. Conduct air testing and balancing with clean filters in place. Clean strainers prior to performing hydronic testing and balancing.
  10. Agent Qualifications: Engage a TAB agent certified by AABC or NEBB.

11. TAB Conference: Meet with the Owner's and the Architect's representatives on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls Installer, and other support personnel. Provide 7 days advance notice of scheduled meeting time and location.
  - a. Agenda Items: Include at least the following:
    - 1) Submittal distribution requirements.
    - 2) Contract Documents examination report.
    - 3) TAB plan.
    - 4) Work schedule and Project site access requirements.
    - 5) Coordination and cooperation of trades and subcontractors.
    - 6) Coordination of documentation and communication flow.
12. Certification of TAB Reports: This certification includes the following:
  - a. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
  - b. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.
13. TAB Reports: Use standard forms from AABC's "National Standards for Testing, Adjusting, and Balancing" and NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."
14. Instrumentation Type, Quantity, and Accuracy: As described in AABC national standards and NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."
15. Instrumentation Calibration: Calibrate instruments at least every 6 months or more frequently if required by the instrument manufacturer.

#### **1.06 WARRANTY**

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
  1. TAB Agency provides warranty for a period of 90 days following submission of completed report, during which time, Owner may request a recheck of up to 10 percent of total number of terminals, or resetting of any outlet, coil, or device listed in the final TAB report.
  2. Guarantee: Meet the requirements of the following programs:
    - a. Provide a guarantee on AABC or NEBB forms stating that the agency will assist in completing the requirements of the Contract Documents if the TAB Agent fails to comply with the Contract Documents. Guarantee includes the following provisions:
      - 1) The certified Agent has tested, adjusted, and balanced systems according to the Contract Documents.
      - 2) Systems are balanced to optimum performance capabilities within design and installation limits.

#### **1.07 DEFINITIONS**

- A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.
- B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to design quantities.
- C. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a persons skin than is normally dissipated.
- D. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
- E. Report Forms: Test data sheets for recording test data in logical order.

- F. **Static Head:** The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.
- G. **Suction Head:** The height of fluid surface above the centerline of the pump on the suction side.
- H. **System Effect:** A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- I. **System Effect Factors:** Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.
- J. **TAB:** Testing, Adjusting, and Balancing.
- K. **Terminal:** A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
- L. **Test:** A procedure to determine quantitative performance of a system or equipment.
- M. **Testing, Adjusting, and Balancing (TAB) Agent:** The entity responsible for performing and reporting the TAB procedures.
- N. **AABC:** Associated Air Balance Council.
- O. **AMCA:** Air Movement and Control Association.
- P. **CTI:** Cooling Tower Institute.
- Q. **NEBB:** National Environmental Balancing Bureau.
- R. **SMACNA:** Sheet Metal and Air Conditioning Contractors' National Association.

## **1.08 COORDINATION**

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
- B. **Notice:** Provide 7 days advance notice for each test. Include scheduled test dates and times.
- C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

## **PART 2 - PRODUCTS - NOT USED**

## **PART 3 - EXECUTION**

### **3.01 GENERAL REQUIREMENTS AND PROCEDURES**

- A. **Project Conditions:**
  - 1. **Non-Owner Occupancy:** Complete balancing of building systems prior to Substantial Completion and owner occupancy.
- B. **General Requirements:**
  - 1. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and controls, coordinate scheduling and testing and inspection procedures with authorities having jurisdiction.
  - 2. Perform TAB work with doors, closed windows, and ceilings installed etc., to obtain simulated or project operating conditions. Do not proceed until systems scheduled for TAB are clean and free from debris, dirt and discarded building materials.
  - 3. Where Owner occupies building during the testing period, cooperate with Owner to minimize conflicts with Owner's operations.
- C. **Examination:**
  - 1. Examine Contract Documents to become familiar with project requirements and existing building record documents (if available) to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
    - a. Contract Documents are defined in the General and Supplementary Conditions of the Contract.

- b. Verify that balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
  2. Examine approved submittal data of HVAC systems and equipment.
  3. Examine project record documents described in Division 01, General Requirements.
  4. Examine Architect's and Engineer's design data, including Basis of Design, 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.
  5. Examine equipment performance data, including fan and pump curves. 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. Calculate system effect factors to reduce the performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.
  6. Coordinate requirements in system and equipment with this Section.
  7. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Specification Sections have been performed.
  8. Examine system and equipment test reports.
  9. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
  10. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
  11. Examine equipment for installation and for properly operating safety interlocks and controls.
  12. Report deficiencies discovered before and during performance of TAB procedures.
  13. Beginning of work means acceptance of existing conditions.
- D. Preparation:
  1. Prepare a TAB plan that includes strategies and step-by-step procedures.
  2. Complete system readiness checks and prepare system readiness reports. Verify the following:
    - a. Permanent electrical power wiring is complete.
    - b. Hydronic systems are filled, clean, and free of air.
    - c. Automatic temperature-control systems are operational.
    - d. Equipment and duct access doors are securely closed.
    - e. Balance, smoke, and fire dampers are open.
    - f. Isolating and balancing valves are open and control valves are operational.
    - g. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
    - h. Windows, doors and other portions of the building envelope can be closed so design conditions for system operations can be met.
  3. Hold a pre-balancing meeting at least one week prior to starting TAB work.
    - a. Attendance is required by installers whose work will be tested, adjusted, or balanced.
  4. Provide instruments required for TAB operations. Make instruments available to Architect to facilitate spot checks during testing.
- E. General TAB Procedures:

1. Perform TAB procedures on each system according to the procedures contained in AABC national standards or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.
  2. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to the insulation Specifications for this Project.
  3. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.
- F. Adjustment Tolerances:
1. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 5 percent of design for return and exhaust systems.
  2. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design. Adjust outlets and inlets in space to within plus or minus 10 percent of design.
  3. Hydronic Systems: Adjust to within plus or minus 10 percent of design at coils and plus or minus 5 percent at system pumps and equipment.
  4. Adjust supply, return, and exhaust air quantities to maintain pressurization in spaces indicated on Drawings. Note and document room-to-room pressurization and maintain these relationships. Adjust pressure controlled spaces to within plus or minus 0.01 in WC.
- G. Recording and Adjusting:
1. Field Logs: Maintain written logs including:
    - a. Running log of events and issues.
    - b. Discrepancies, deficient or uncompleted work by others.
    - c. Contract interpretation requests.
    - d. Lists of completed tests.
  2. Ensure recorded data represents actual measured or observed conditions.
  3. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
  4. Mark on drawings locations where traverse and other critical measurements were taken and cross reference location in final report.
  5. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
  6. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
  7. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by Owner's Representative, or Commissioning Agent.

### **3.02 FUNDAMENTAL AIR SYSTEMS BALANCING PROCEDURES**

- A. Examine air-handling equipment to ensure clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- B. Examine terminal units, such as variable-air-volume boxes and mixing boxes, to verify that they are accessible and their controls are connected and functioning.
- C. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- D. Prepare test reports for both fans and inlets and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross check the summation of required outlet volumes with required fan volumes.
- E. Prepare schematic diagrams of systems' "as-built" duct layouts.
- F. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- G. Check the airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

- H. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- I. Verify that motor starters are equipped with thermal protection, sized for the connected load.
- J. Check dampers for proper position to achieve desired airflow path.
- K. Check for airflow blockages.
- L. Check that condensate drains are installed, trapped and primed and routed to drain.
- M. Check for readily observable leaks in air-handling unit components and ductwork.
- N. Use sheaves and pulleys to adjust the speed of belt drive fans to achieve design flow with motors running at 60 Hertz unless noted otherwise.

### **3.03 TEMPERATURE CONTROL VERIFICATION**

- A. Examine automatic temperature system components to verify the following:
  - 1. Dampers, valves, and other controlled devices operate by the intended controller.
  - 2. Dampers and valves are in the position indicated by the controller.
  - 3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
  - 4. Automatic modulating and shutoff valves, including 2-way valves and 3-way mixing and diverting valves, are properly connected.
  - 5. Thermostats and humidistats are located to avoid adverse effects of sunlight, equipment, drafts, and cold walls.
  - 6. Sensors are located to sense only the intended conditions.
  - 7. Sequence of operation for control modes is according to the Contract Documents.
  - 8. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.
  - 9. Interlocked systems are operating.
  - 10. Changeover from heating to cooling mode occurs according to design values.
- B. Verify that controllers are calibrated and commissioned.
- C. Check transmitter and controller locations and note conditions that would adversely affect control functions.
- D. Record controller settings and note variances between set points and actual measurements.
- E. Verify operation of limiting controllers (i.e., high- and low-temperature controllers).
- F. Verify free travel and proper operation of control devices such as damper and valve operators.
- G. Verify sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water-flow measurements. Note the speed of response to input changes.
- H. Confirm interaction of electrically operated switch transducers.
- I. Confirm interaction of interlock and lockout systems.
- J. Verify main control supply-air pressure and observe compressor and dryer operations.
- K. Note operation of electric actuators using spring return for proper fail-safe operations.

### **3.04 CONSTANT VOLUME AIR SYSTEMS BALANCING PROCEDURES**

- A. Adjust fans to deliver total design airflows within the maximum allowable rpm listed by the fan manufacturer. Adjust fans to deliver design airflow at the lowest possible speed.
  - 1. Measure fan static pressures to determine actual static pressure as follows:
    - a. Measure outlet static pressure as far downstream from the fan as practicable 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 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.
2. Measure static pressure across each air-handling unit component under final balanced condition.
3. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Recommend corrective action to align design and actual conditions.
4. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
5. Do not make fan-speed adjustments that result in motor loading greater than full load amps. Do not increase fan speed beyond fan class rating. Modulate dampers and measure fan-motor amperage to ensure no overload will occur. Measure amperage in full cooling, full heating, and economizer modes to determine the maximum required brake horsepower.
6. Adjust volume dampers for main duct, submain ducts, and major branch ducts to design airflows within specified tolerances.
7. Calibrate airflow measuring stations.

### **3.05 PRE-BALANCE REPORTING**

- A. Pre-Construction Phase Report:
  1. Provide a pre-construction phase TAB Plan at least 2 weeks prior to the commencement of TAB work. This report is to include:
    - a. A complete set of report forms intended for use on the project, with all data filled in except for the field readings. Forms to be project specific.
    - b. Marked up shop drawings identifying all HVAC equipment to be balanced, and associated outlets and terminal devices.
    - c. Identification of the type, manufacturer, and model of actual instruments to be used, and clear indication of which instrument will be used to take each type of reading. Calibration certifications are to be included.
    - d. A narrative of any project specific and/or non-standard TAB procedures to be used, and the equipment or systems they apply to.
- B. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article above, 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.
- C. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced.

### **3.06 FINAL REPORTS**

- A. Report Requirements:
  1. General:
    - a. Computer printout in letter-quality font, on standard bond paper, in 3-ring binder, tabulated and divided into sections by tested and balanced systems.
    - b. Include a certification sheet in front of binder signed and sealed by the certified TAB engineer.
      - 1) Include a list of the instruments used for procedures, along with proof of calibration.
    - c. Final Report Contents: In addition to the certified field report data, include the following:
      - 1) Pump curves.
      - 2) Fan Curves
      - 3) Manufacturers Test Data



- 4) Field test reports prepared by system and equipment installers.
  - 5) Other information relative to equipment performance, but do not include approved Shop Drawings and Product Data.
- B. General Report Data:**
1. In addition to the form titles and entries, include the following data in the final report, as applicable:
    - a. Title Page
    - b. Name and Address of TAB Agent
    - c. Project Name
    - d. Project Location
    - e. Architect's Name and Address
    - f. Engineer's Name and Address
    - g. Contractor's Name and Address
    - h. Report Date
    - i. Signature of TAB Agent who Certifies the Report
    - j. Summary of Contents, Including the Following:
      - 1) Design versus Final Performance
      - 2) Notable Characteristics of Systems
      - 3) Description of System Operation Sequence if it varies from the Contract Documents
    - k. Nomenclature Sheets for Each Item of Equipment
    - l. Data for Terminal Units, including Manufacturer, Type Size, and Fittings
    - m. Notes to explain why certain final data in the body of reports vary from design values.
    - n. Test Conditions for Fans and Pump Performance Forms, Including the Following:
      - 1) Settings for Outside-, Return-, and Exhaust-air Dampers
      - 2) Conditions of Filters
      - 3) Cooling Coil, Wet- and Dry-bulb Conditions
      - 4) Face and Bypass Damper Settings at Coils
      - 5) Fan Drive Settings, including Settings and Percentage of Maximum Pitch Diameter
      - 6) Inlet Vane Settings for Variable-Air-Volume Systems
      - 7) Settings for Supply-air, Static-pressure Controller
      - 8) Other System Operating Conditions that affect Performance
- C. System Diagrams:**
1. Include schematic layouts of air and hydronic distribution systems. Present with single-line diagrams and include the following:
    - a. Quantities of Outside, Supply, Return, and Exhaust Airflows
    - b. Water and Steam Flow Rates
    - c. Duct, Outlet, and Inlet Sizes
    - d. Pipe and Valve Sizes and Locations
    - e. Terminal Units
    - f. Balancing Stations
- D. Refrigerant Coils:**
1. For refrigerant coils in all equipment with coils, include the following:
    - a. Coil Data: Include the following:
      - 1) System Identification
      - 2) Location and Zone
      - 3) Room or Riser Served
      - 4) Coil Type
      - 5) Number of Rows
      - 6) Fin Spacing in Fins per Inch o.c.
      - 7) Make and Model Number
      - 8) Face Area in SF

- 9) Tube Size in NPS (DN)
- 10) Tube and fin Materials
- 11) Circuiting Arrangement
- b. Test Data: Include design and actual values for the following:
  - 1) Airflow Rate in cfm
  - 2) Average Face Velocity in fpm
  - 3) Air Pressure Drop in Inches wg
  - 4) Outside-air, Wet- and Dry-bulb Temperatures in Degrees F
  - 5) Return-air, Wet- and Dry-bulb Temperatures in Degrees F
  - 6) Entering-air, Wet- and Dry-bulb Temperatures in Degrees F
  - 7) Leaving-air, Wet- and Dry-bulb Temperatures in Degrees F
  - 8) Refrigerant Expansion Valve and Refrigerant Types
  - 9) Refrigerant Suction Pressure in PSIG
  - 10) Refrigerant Suction Temperature in Degrees F
- E. Fans:
  - 1. Fan Test Reports: For supply, return, and exhaust fans, include the following:
    - a. Fan Data: Include the following:
      - 1) System Identification
      - 2) Location
      - 3) Make and Type
      - 4) Model Number and Size
      - 5) Manufacturer's Serial Number
      - 6) Arrangement and Class
      - 7) Sheave Make, Size in Inches, and Bore
      - 8) Sheave Dimensions, Center-to-center and Amount of Adjustments in Inches.
    - b. Motor Data: Include the following:
      - 1) Make and Frame Type and Size
      - 2) Horsepower and rpm
      - 3) Volts, Phase, and Hertz
      - 4) Full-load Amperage and Service Factor
      - 5) Sheave Make, Size in Inches, and Bore
      - 6) Sheave Dimensions, Center-to-center and Amount of Adjustments in Inches
      - 7) Number of Belts, Make, and Size
    - c. Test Data: Include design and actual values for the following:
      - 1) Total Airflow Rate in cfm
      - 2) Total System Static Pressure in Inches wg
      - 3) Fan rpm
      - 4) Discharge Static Pressure in Inches wg
      - 5) Suction Static Pressure in Inches wg
- F. Duct Traverses:
  - 1. Include a diagram with a grid representing the duct cross-section and record the following:
    - a. Report Data: Include the following:
      - 1) System and Air-handling Unit Number
      - 2) Location and Zone
      - 3) Traverse Air Temperature in Degrees F
      - 4) Duct Static Pressure in Inches wg
      - 5) Duct Size in Inches
      - 6) Duct Area in SF
      - 7) Design Airflow Rate in cfm
      - 8) Design Velocity in fpm
      - 9) Actual Airflow Rate in cfm
      - 10) Actual Average Velocity in fpm
      - 11) Barometric Pressure in PSIG

**G. Diffusers/Registers/Grilles:**

1. For diffusers, registers and grilles, include the following:
  - a. Unit Data: Include the following:
    - 1) System and Air-handling Unit Identification
    - 2) Location and Zone
    - 3) Test Apparatus Used
    - 4) Area Served
    - 5) Air-terminal-device Make
    - 6) Air-terminal-device Number from System Diagram
    - 7) Air-terminal-device Type and Model Number
    - 8) Air-terminal-device Size
    - 9) Air-terminal-device Effective Area in SF
  - b. Test Data: Include design and actual values for the following:
    - 1) Airflow Rate in cfm
    - 2) Air Velocity in fpm
    - 3) Preliminary Airflow Rate as Needed in cfm
    - 4) Preliminary Velocity as Needed in fpm
    - 5) Final Airflow Rate in cfm
    - 6) Final Velocity in fpm
    - 7) Space Temperature in Degrees F

**H. Compressor and Condensers:**

1. For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units, or water-cooled condensing units, include the following:
  - a. Unit Data: Include the following:
    - 1) Unit Identification
    - 2) Location
    - 3) Unit Make and Model Number
    - 4) Manufacturer's Compressor Serial Numbers
    - 5) Compressor Make
    - 6) Compressor Model and Serial Numbers
    - 7) Refrigerant Weight in Pounds
    - 8) Low Ambient Temperature Cutoff in Degrees F
  - b. Test Data: Include design and actual values for the following:
    - 1) Inlet-duct Static Pressure in Inches wg
    - 2) Outlet-duct Static Pressure in Inches wg
    - 3) Entering-air, Dry-bulb Temperature in Degrees F
    - 4) Leaving-air, Dry-bulb Temperature in Degrees F
    - 5) Condenser Entering-water Temperature in Degrees F
    - 6) Condenser Leaving-water Temperature in Degrees F
    - 7) Condenser Water Temperature Differential in Degrees F
    - 8) Condenser Entering-water Pressure in Feet of Head or PSIG
    - 9) Condenser Leaving-water Pressure in Feet of Head or PSIG
    - 10) Condenser Water Pressure Differential in Feet of Head or PSIG
    - 11) Control Settings
    - 12) Unloader Set Points
    - 13) Low-pressure-cutout Set Point in PSIG
    - 14) High-pressure-cutout Set Point in PSIG
    - 15) Suction Pressure in PSIG
    - 16) Suction Temperature in Degrees F
    - 17) Condenser Refrigerant Pressure in PSIG
    - 18) Condenser Refrigerant Temperature in Degrees F
    - 19) Oil Pressure in PSIG
    - 20) Oil Temperature in Degrees F

- 21) Voltage at Each Connection
- 22) Amperage for Each Phase
- 23) The kW Input
- 24) Crankcase Heater kW
- 25) Number of Fans
- 26) Condenser Fan rpm
- 27) Condenser Fan Airflow Rate in cfm
- 28) Condenser Fan Motor Make, Frame Size, rpm, and Horsepower
- 29) Condenser Fan Motor Voltage at Each Connection
- 30) Condenser Fan Motor Amperage for Each Phase

I. Instrument Calibration:

1. For instrument calibration, include the following:
  - a. Report Data: Include the following:
    - 1) Instrument Type and Make
    - 2) Serial Number
    - 3) Application.
    - 4) Dates of Use
  - b. Dates of Calibration.

**3.07 ADDITIONAL TESTS**

- A. Within 90 days of completing TAB, perform additional testing and balancing 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 inspections, testing, and adjusting during near-peak summer and winter conditions.

**END OF SECTION**

**SECTION 23 07 00**  
**HVAC INSULATION**

**PART 1 - GENERAL****1.01 SUMMARY**

- A. Work Included:
  - 1. Type A, Flexible Glass Wool Blanket
  - 2. Type B, Duct Liner
  - 3. Type 1, Glass Wool Pipe Insulation
  - 4. Type 2, Flexible Elastomeric Pipe Insulation
  - 5. Jacketing
  - 6. Accessories
  - 7. Duct Insulation Accessories
  - 8. Duct Insulation Compounds
  - 9. Outdoor Ducting Cover

**1.02 RELATED SECTIONS**

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

**1.03 REFERENCES AND STANDARDS**

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
  - 1. Piping and duct insulation products to contain less than 0.1 percent by weight PBDE in all insulating materials.

**1.04 SUBMITTALS**

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
  - 1. Installer qualifications.
  - 2. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any) for each type of product indicated.
  - 3. 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.
  - 4. Installer Certificates: Signed by the Contractor certifying that installers comply with requirements.
  - 5. Submit manufacturer's installation instructions.

**1.05 QUALITY ASSURANCE**

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
  - 1. Formaldehyde Free: Should be third-party certified with UL Environment Validation.
  - 2. Recycled Content: A minimum of 40 percent post-consumer recycled glass content certified and UL validated.
  - 3. Low Emitting Materials: For all thermal and acoustical applications of Glass Mineral Wool Insulation products, provide materials complying with the testing and products requirements of UL GREENGUARD Gold Certification.
  - 4. Installer to have minimum 5 years' experience in the business of installing insulation.

**1.06 WARRANTY**

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

**1.07 FIRE HAZARD CLASSIFICATION**

- A. Maximum fire hazard classification of the composite insulation construction as installed to be not more than a Flame Spread Index (FSI) of 25 and Smoke Developed Index (SDI) of 50 as tested by current edition of ASTM E84 (NFPA 255) method.
- B. Test pipe insulation in accordance with the requirements of current edition of UL "Pipe and Equipment Coverings R5583 400 8.15".
- C. Test duct insulation in accordance with current edition of ASTM E84, UL 723, NFPA 255, NFPA 90A and NFPA 90B.

**PART 2 - PRODUCTS****2.01 MANUFACTURERS**

- A. Type A, Flexible Glass Wool Blanket:
  - 1. Certainteed
  - 2. Johns Manville
  - 3. Knauf
  - 4. Owens-Corning
  - 5. Or approved equivalent.
- B. Type B, Duct Liner:
  - 1. Certainteed
  - 2. Johns Manville
  - 3. Knauf
  - 4. Owens-Corning
  - 5. Or approved equivalent.
- C. Type 1, Glass Wool Pipe Insulation:
  - 1. Certainteed
  - 2. Johns Manville
  - 3. Knauf
  - 4. Owens-Corning
  - 5. Or approved equivalent.
- D. Type 2, Flexible Elastomeric Pipe Insulation:
  - 1. Glue:
    - a. Armacell LLC Armaflex Low VOC Adhesive
    - b. Halstead
    - c. Or approved equivalent.
  - 2. Paint:
    - a. Armacell LLC Armaflex
    - b. Halstead
    - c. Or approved equivalent.
- E. Jacketing:
  - 1. ITW Insulation Systems
  - 2. Or approved equivalent.
- F. Accessories:
  - 1. ITW Insulation Systems
  - 2. Or approved equivalent.
- G. Duct Insulation Accessories:
  - 1. Certainteed
  - 2. Johns Manville
  - 3. Owens-Corning

- 4. Or approved equivalent.
- H. Duct Insulation Compounds:
  - 1. Certaineed
  - 2. Johns Manville
  - 3. Owens-Corning
  - 4. Or approved equivalent.
- I. Outdoor Ducting Cover:
  - 1. Certaineed
  - 2. Johns Manville
  - 3. Owens-Corning
  - 4. Or approved equivalent.

## **2.02 TYPE A, FLEXIBLE GLASS WOOL BLANKET**

- A. ASTM C553, Type 1, Class B-2; flexible blanket.
- B. 'K' Value: 0.27 BTU\*in/(hr\*sf°F) at 75 degrees F installed, maximum service temperature: 250 degrees F.
- C. Density: 0.75 pounds per cubic foot.
- D. Vapor Barrier Jacket: FSK aluminum foil reinforced with glass wool yarn and laminated to fire resistant Kraft, secured with UL listed pressure sensitive tape or outward clinched expanded staples and vapor barrier mastic as needed.
- E. DBDE-free. UL/E validated to be formaldehyde-free.

## **2.03 TYPE B, DUCT LINER**

- A. ASTM C1071; flexible blanket.
- B. 'K' Value: ASTM C518, 0.25 BTU\*in/(hr\*sf°F) at 75 degrees F, maximum service temperature: 250 degrees F.
- C. Noise Reduction Coefficient: 0.65 or higher based on ASTM C 423 "Type A mounting."
- D. Maximum Velocity on Mat or Coated Air Side: 5,000 FPM.
- E. Adhesive: UL listed waterproof type.
- F. Fasteners: Duct liner galvanized steel pins, welded or mechanically fastened.
- G. Erosion-Resistant Surfaces: UL 181.
- H. ASTM G21 and ASTM G22 Microbial Growth Resistance.
- I. UL GREENGUARD Certified does not support the growth of mold, fungi, or bacteria per ASTM C 1338 and meets UL Environment GREENGUARD Microbial Resistance Listing per UL 2824-"GREENGUARD Certification Program Method for Measuring Microbial Resistance". DBDE-free. UL/E validated to be formaldehyde-free.

## **2.04 TYPE 1, GLASS WOOL PIPE INSULATION**

- A. Glass Wool: ASTM C547 Type I and IV; rigid molded, noncombustible.
  - 1. Thermal Conductivity Value: As indicated in the insulation tables below.
  - 2. Maximum Service Temperature: 850 degrees F to 1000 degrees F.
  - 3. Vapor Retarder Jacket: White Kraft paper reinforced with glass wool and bonded to aluminum foil, secure with self-sealing longitudinal laps and butt strips or vapor barrier mastic.

## **2.05 TYPE 2, FLEXIBLE ELASTOMERIC PIPE INSULATION**

- A. Elastomeric Foam: ASTM C534; flexible, cellular elastomeric, molded or sheet.
  - 1. Thermal Conductivity Value: As indicated in the insulation tables below.
  - 2. Maximum Service Temperature of 220 degrees F.
  - 3. Maximum Flame Spread: 25.
  - 4. Maximum Smoke Developed: 50 (1-inch thick and below).
  - 5. Connection: Waterproof vapor retarder adhesive as needed.

- 6. UV Protection: UV outdoor protective coating per manufacturer's requirements.
- B. Glue: Contact adhesive specifically manufactured for cementing flexible elastomeric foam. Armacell LLC Armaflex Low VOC adhesive, Halstead, or approved equivalent.
- C. Paint: Nonhardening high elasticity type, specifically manufactured as protective covering of flexible elastomeric foam insulation for prevention of degradation due to exposure to sunlight and weather. Armacell LLC Armaflex, Halstead, or approved equivalent.

## **2.06 JACKETING**

- A. Canvas Jacket: UL listed fabric, 6 ounce/sq. yd., plain weave cotton treated with dilute fire retardant lagging adhesive.
- B. PVC preformed molded insulation covers. Zeston or approved equivalent.
- C. Aluminum Jacket: 0.016-inch-thick sheet, (smooth/embossed) finish, with longitudinal slip joints and 2-inch laps, die-shaped fitting covers with factory attached protective liner.
- D. Stainless Steel Jacket: Type 304 stainless steel, 0.010-inch, smooth finish.

## **2.07 ACCESSORIES**

- A. Equipment Insulation Jacketing: Presized glass cloth, not less than 7.8 ounces/sq.yd., except as otherwise indicated. Coat with gypsum based cement.
- B. Equipment Insulation Compounds: Provide adhesives, cement, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.
- C. General: Provide staples, bands, wire, wire netting, tape corner angles, anchors, stud pins and metal covers as recommended by insulation manufacturer for applications indicated. Accessories, i.e., adhesives, mastics, cements and tape to have the same flame and smoke component ratings as the insulation materials with which they are used. Shipping cartons to bear a label indicating that flame and smoke ratings do not exceed those listed above. Provide permanent treatment of jackets or facings to impart flame and smoke safety. Provide nonwater soluble treatments. Provide UV protection recommended by manufacturer for outdoor installation.

## **2.08 DUCT INSULATION ACCESSORIES**

- A. Staples, bands, wires, tape, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.

## **2.09 DUCT INSULATION COMPOUNDS**

- A. Cements, adhesives, coatings, sealers, protective finishes and similar accessories as recommended by insulation manufacturer for applications indicated.

## **2.10 OUTDOOR DUCTING COVER**

- A. Aluminum Jacket: 0.016-inch-thick sheet, smooth/embossed finish, with longitudinal slip joints and 2-inch laps.
- B. Nonwater vapor retarder, nonburning, weatherproof coating for use over insulation where "breathing" is required.
- C. UV resistant polyvinyl chloride covering with joints secured and sealed.

## **PART 3 - EXECUTION**

### **3.01 GENERAL INSTALLATION REQUIREMENTS**

- A. Verification of Conditions:
  - 1. Do not apply insulation until pressure testing and inspection of ducts and piping has been completed.
  - 2. Examine areas and conditions under which duct and pipe insulation will be installed. Do not proceed with work until unsatisfactory conditions have been corrected.
- B. Preparation: Clean and dry surfaces to be insulated.
- C. Installation:



1. Insulation: Continuous through walls, floors and partitions except where noted otherwise.
2. Piping and Equipment:
  - a. Install insulation over clean, dry surfaces with adjoining sections firmly butted together and covering surfaces. Fill voids and holes. Seal raw edges. Install insulation in a manner such that insulation may be split, removed, and reinstalled with vapor barrier tape on strainer caps and unions. Do not install insulation until piping has been leak tested and has passed such tests. Do not insulate manholes, equipment manufacturer's nameplates, handholes, and ASME stamps. Provide beveled edge at such insulation interruptions. Repair voids or tears.
  - b. Cover insulation on pipes above ground, outside of building, with aluminum jacketing. Position seam on bottom of pipe.
- D. Provide accessories as required. See Part 2 Article "Accessories" above.
- E. Protection and Replacement: Installed insulation during construction. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.
- F. Glass Wool Insulation:
  1. Lap seal insulation with waterproof adhesive. Do not use staples or other methods of attachment which would penetrate the vapor barrier. Apply fitting covers with seated tacks and vapor barrier tape.
  2. Apply insulation to pipe and seal with self-sealing lap. Use self-sealing butt strips to seal butt joints. Insulate fittings, valves and unions with single or multiple layers of insulation and cover to match pipe or use performed PVC molded insulation covers.
- G. Labeling and Marking: Provide labels, arrows and color on piping and ductwork. Attach labels and flow direction arrows to the jacketing per Section 23 05 53, Identification for HVAC Piping, Ductwork and Equipment.
- H. Ductwork:
  1. Install insulation in conformance with manufacturer's recommendations to completely cover duct.
  2. Butt insulation joints firmly together and install jackets and tapes smoothly and securely.
  3. Apply duct insulation continuously through sleeves and prepared openings, except as otherwise specified. Apply vapor barrier materials to form complete unbroken vapor seal over insulation.
  4. Coat staples and seals with vapor barrier coating.
  5. Cover breaks in jacket materials with patches of same material as vapor barrier. Extend patches not less than 2-inches beyond break or penetration on all directions and secure with adhesive and staples. Seal staples and joints with vapor barrier coating.
  6. Fill jacket penetrations. i.e., hangers, thermometers and damper operating rods, and other voids in insulation with vapor barrier coating. Seal penetration with vapor barrier coating. Insulate Hangers and Supports for cold duct in un-conditioned spaces to extent to prevent condensation on surfaces.
  7. Seal and flash insulation terminations and pin punctures with reinforced vapor barrier coating.
  8. Continue insulation at fire dampers and fire/smoke dampers up to and including those portions of damper frame visible at outside of the rated fire barrier. Insulating terminations at fire dampers in accordance with this Section.
  9. Do not conceal duct access doors with insulation. Install insulation terminations at access door in accordance with this Section.
- I. Insulated Pipe Exposed to Weather: Where piping is exposed to weather, cover insulation with aluminum jacket. Seal watertight jacket per manufacturer's recommendations. Install metal jacket with 2-inch overlap at longitudinal and butt joints with exposed lap pointing down. Secure jacket with stainless-steel draw bands 12-inches on center and at butt joints.
- J. Insulation Shields: Provide hangers and shields (18 gauge minimum) outside of insulation for cold piping (<60 degrees F). Hot water piping hangers may penetrate insulation to contact pipe

directly. Provide 18-inch long, noncompressible insulation section at insulation shields for lines 2-inches and larger for steam and chilled water piping.

**K. Ductwork Surfaces to be Insulated:**

Item to be Insulated	System Insulation Type	Duct Size	Insulation Thickness
Supply ductwork where duct is not specified to be lined.	A	All	1-1/2-inch
Return ductwork where duct is not specified to be lined or where ductboard is not utilized.	—	All	None

- Note: Insulation thickness shown is a minimum. If state codes require additional thickness, then provide insulation thickness per code requirements.

**L. Piping Surfaces to be Insulated:**

Item to be Insulated	System Insulation Type	Conductivity Range (Btu-inch per hour per SF per degrees F)	Pipe Size (inches)	Insulation Thickness (inches)
Refrigerant Suction Piping (40F to 60F)	2	0.21-0.27 at a mean rating temperature of 75 degrees F	<1 1 to <1.5 1.5 to <4 4 to <8 ≥ 8	0.5 0.5 1.0 1.0 1.0
Refrigerant Suction Piping (≤40F)	2	0.20-0.26 at a mean rating temperature of 50 degrees F	<1 1 to <1.5 1.5 to <4 4 to <8 ≥ 8	0.5 1.0 1.0 1.0 1.5

- Note: Insulation thickness shown is a minimum. If state code requires additional thickness, then provide insulation thickness per code requirements.

### 3.02 TYPE A, FLEXIBLE GLASS WOOL BLANKET

- Install insulation in conformance with manufacturer's recommendations and requirements.
- Duct Wrap: Cover air ducts per insulation table except ducts internally lined where internal duct lining is adequate to achieve adequate insulating values to meet local Energy Codes (indicate on shop drawings, locations where duct wrap is planned to be omitted and indicate internal duct lining insulating values to confirm they will meet the Energy Code.) Wrap tightly with circumferential joints butted and longitudinal joints overlapped minimum of 2-inches. On ducts

over 24-inches wide, additionally secure insulation with suitable mechanical fasteners at 18-inches on center. Circumferential and longitudinal joints stapled with flare staples 6-inches on center and covered with 3-inch wide, foil reinforced tape.

### **3.03 TYPE B, DUCT LINER**

- A. Install insulation in conformance with manufacturer's recommendations and requirements.
- B. Duct Liners: Mat finish surface on air stream side. Secure insulation to cleaned sheet metal duct with continuous (minimum 90) percent coat of adhesive. Secure liner with mechanical fasteners 15-inches on center or per manufacturer requirements. Accurately cut liner and thoroughly coat ends with adhesive. Butt joints tightly. Top and bottom Sections of insulation overlap sides. Factory/field coat exposed edges. Metal nosing for exposed leading or transverse edges and when velocity exceeds 3500 FPM or manufacturer rating on exposed edges. Keep duct liner clean and free from dust. At completion of project, vacuum duct liner if it is dirty or dusty. Do not use small pieces. If insulation is installed without horizontal, longitudinal, and end joints butted together, installation will be rejected and work removed and replaced with work that conforms to this Specification.

### **3.04 TYPE 1, GLASS WOOL PIPE INSULATION**

- A. Install insulation in conformance with manufacturer's recommendations and requirements.
- B. See General Installation Requirements above.
- C. Lap seal insulation with waterproof adhesive. Do not use staples or other methods of attachment which would penetrate vapor barrier. Apply fitting covers with seated tacks and vapor barrier tape.
- D. Apply insulation to pipe and seal with self-sealing lap. Use self-sealing butt strips to seal butt joints. Insulate fittings, valves and unions with single or multiple layers of insulation and cover to match pipe or use preformed PVC molded insulation covers.
- E. Insulation Shields: Provide hangers and shields (18 gauge minimum) outside of insulation for cold piping (<60 degrees F). Hot water piping hangers may penetrate insulation to contact pipe directly. Provide 18-inch long, noncompressible insulation section at insulation shields for lines 2-inches and larger (hot and cold piping).

### **3.05 TYPE 2, FLEXIBLE ELASTOMERIC PIPE INSULATION**

- A. Flexible Elastomeric Insulation:
  - 1. Slip insulation on pipe prior to connection. Butt joints sealed with manufacturer's adhesive. Insulate fitting with miter-cut pieces. Cover insulation exposed to weather and below grade with two coats of finish as recommended by manufacturer.
- B. Flexible Elastomeric Tubing:
  - 1. Flexible Elastomeric Tubing: Slip insulation over piping or, if piping is already installed, slit insulation and snap over piping. Joints and butt ends must be adhered with 520 adhesive.
- C. Install insulation in conformance with manufacturer's recommendations and requirements.
- D. See General Installation Requirements above.
- E. Slip insulation on pipe prior to connection. Butt joints sealed with manufacturer's adhesive. Insulate fitting with miter-cut pieces. Cover insulation exposed to weather and undergrade with two coats of finish as recommended by manufacturer.
- F. Insulation Shields: Provide hangers and shields (18 gauge minimum) outside of insulation for cold piping (<60 degrees F). Hot water piping hangers may penetrate insulation to contact pipe directly. Provide 18-inch long, noncompressible insulation section at insulation shields for lines 2-inches and larger (hot and cold piping).
- G. Install in accordance with manufacturer's instructions for below grade installation.

### **3.06 JACKETING**

- A. See General Installation Requirements above.
- B. Install in accordance with manufacturer's instructions.

**3.07 ACCESSORIES**

- A. Install insulation in conformance with manufacturer's instructions, recommendations and requirements.
- B. See General Installation Requirements above.
- C. Provide and install accessories for all insulation types listed in this Section.

**3.08 DUCT INSULATION ACCESSORIES**

- A. Install insulation in conformance with manufacturer's recommendations and requirements.

**3.09 DUCT INSULATION COMPOUNDS**

- A. Install insulation in conformance with manufacturer's recommendations and requirements.

**3.10 OUTDOOR DUCTING COVER**

- A. Install insulation in conformance with manufacturer's recommendations and requirements.
- B. Outdoor Duct Exposed to Weather:
  - 1. Install jacket with brakes/slope to prevent standing water on duct. Use weatherable components.
  - 2. Weatherproof seal at joints and seams. Minimum 2-inch overlap.
  - 3. Label jacket every 6-feet and within 2-feet of building penetrations and equipment connections: "Do not stand or place equipment on duct."

**END OF SECTION**

**SECTION 23 21 13**  
**HVAC PIPING**

**PART 1 - GENERAL**

**1.01 SUMMARY**

- A. Work Included:
  - 1. Heating Water Piping, Above Ground
  - 2. Refrigerant Piping

**1.02 RELATED SECTIONS**

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

**1.03 REFERENCES AND STANDARDS**

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

**1.04 SUBMITTALS**

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
  - 1. Welding Certificates: Copies of certificates for welding procedures and personnel.
  - 2. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:
    - a. Test procedures used.
    - b. Test results that comply with requirements.
    - c. Failed test results and corrective action taken to achieve requirements.
  - 3. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at project site.
  - 4. Buried piping manufacturer to submit thrust block (chilled water) and anchor plate (heating hot water) layout and details including anchorage and seismic calculations.

**1.05 QUALITY ASSURANCE**

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
  - 1. Installer Qualifications: Company specializing in performing work of the type specified in this Section, with documented experience.
  - 2. Welder Qualifications: Certify in accordance with ASME (BPV IX).
  - 3. ASME Compliance: Comply with ASME B31.9 "Building Services Piping" for materials, products, and installation. Provide safety valves and pressure vessels with the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 01.
  - 4. Refrigerant Piping:
    - a. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX "Welding and Brazing Qualifications."
    - b. ASHRAE Standard: Comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
    - c. ASME Standard: comply with ASME B31.5, "Refrigeration Piping."
    - d. UL Standard: Provide products complying with UL 207, "Refrigerant-Containing Components and Accessories, Nonelectrical" or UL 429 "Electrically Operated Valves."

**1.06 WARRANTY**

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements, General Requirements.

## **PART 2 - PRODUCTS**

### **2.01 HEATING WATER PIPING, ABOVE GROUND**

- A. Steel Pipe: ASTM A53/A 53M, Schedule 40, black, Type E (electric resistance welded), Grade B.
  - 1. Fittings: ASME B16.3, malleable iron or ASTM A 234/A 234M, wrought steel welding type.
  - 2. Wrought Cast and Forged Steel Flanges and Flanged Fittings: ASME B16.5 including bolts, nuts, and gaskets of the following material group, end connections, and facings:
    - a. Material Group: 1.1.
    - b. End Connections: Butt welding.
    - c. Facings: Raised face.
  - 3. Joints: Threaded or AWS D1.1 welded.
- B. Copper Tube: ASTM B 88 (ASTM B 88M), Type L (B), drawn.
  - 1. Fittings: ASME B16.18, cast brass, or ASME B16.22, solder wrought copper.
  - 2. Joints: Solder, lead free ASTM B32, HB alloy (95-5 tin antimony), or tin and silver.
  - 3. Joints: Braze, AWS A5.8, Classification BAg-1 (silver). Pipes 2-1/2-inches or larger or piping routed over food preparation centers, food serving facilities, food storage areas, computer rooms, telecommunications rooms, and electrical rooms.

### **2.02 REFRIGERANT PIPING**

- A. Piping:
  - 1. Copper Tube: ASTM B 280, Type ACR, drawn-temper tube, clean, dry and capped.
    - a. Fittings: ASME B16.22 wrought copper.
    - b. Joints: Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy (15 percent Silver).
  - 2. Copper Tube to 5/8-inch OD: ASTM B280. Tube ACR, annealed-temper copper tube, clean, dry and capped.
    - a. Fittings: ASME B16.26 cast copper.
    - b. Joints: Flared.

## **PART 3 - EXECUTION**

### **3.01 GENERAL INSTALLATION REQUIREMENTS**

- A. Install per manufacturer's written instructions and requirements.
- B. Preparation:
  - 1. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
  - 2. Remove scale and dirt on inside and outside before assembly.
  - 3. Prepare piping connections to equipment with flanges or unions.
  - 4. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
- C. Above Ground Piping Installation:
  - 1. Install per manufacturer's written instructions and requirements.
  - 2. Install heating water, glycol, condenser water, piping to ASME B31.9 requirements. Install chilled water piping to ASME B31.5 requirements.
  - 3. PVC Pipe: Make solvent-welded joints in accordance with ASTM D 2855.
  - 4. Route piping in orderly manner, parallel to building structure, and maintain gradient.
  - 5. Install piping to conserve building space and to avoid interference with use of space.
  - 6. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
  - 7. Sleeve pipe passing through partitions, walls and floors allowing adequate space for pipe insulation.
  - 8. Slope piping at 0.2 percent upward in direction of flow and arrange to drain at low points.
  - 9. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

10. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
  11. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.
  12. Anchor piping for proper direction of expansion and contraction.
  13. Inserts:
    - a. Provide inserts for placement in concrete formwork.
    - b. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
    - c. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4-inches.
    - d. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
    - e. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut flush with top of slab.
  14. Pipe Hangers and Supports:
    - a. Install in accordance with Division 23, HVAC, Hangers and Supports.
    - b. Install hangers to provide minimum 1/2-inch space between finished covering and adjacent work.
    - c. Place hangers within 12-inches of each horizontal elbow.
    - d. Use hangers with 1-1/2-inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
    - e. Support vertical piping at every floor. Support riser piping independently of connected horizontal piping.
    - f. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
    - g. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.
    - h. Provide copper plated hangers and supports for copper piping.
    - i. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
  15. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
  16. Provide access where valves and fittings are not exposed.
  17. Use eccentric reducers to maintain top of pipe level.
  18. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.
  19. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.
- D. Field Quality Control:
1. Leave joints, including welds, uninsulated and exposed for examination during test.
  2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
  3. Flush system with clean water. Clean strainers.
  4. Isolate equipment from piping. If a valve is used to isolate equipment, provide closure capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
  5. 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.
  6. Perform the following tests on hydronic piping:
    - a. 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.
    - b. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.

- c. Check expansion tanks to determine that they are not air bound and that system is full of water.
  - d. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure not-to-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 either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."
  - e. After hydrostatic test pressure has been applied for at least four 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.
  - f. Prepare written report of testing.
- E. Flushing and Cleaning of Piping Systems:
- 1. Clean piping systems thoroughly. Purge pipe of construction debris and contamination before placing the piping systems in service. Provide temporary connections for cleaning, purging, and circulating fluids through the piping system.
  - 2. Use temporary strainers and temporary pumps that can create fluid velocities up to 10 feet per second to flush and clean the piping systems. Do not use Owner's permanent strainers to trap debris during pipe flushing operations. Fit the temporary construction strainers with a line size blowoff valve.
  - 3. When constructing minor piping modifications or additions, verify with Owner if the Owner's pumps and strainers can be used for flushing and chemical cleaning operations. When the flushing and cleaning operations are complete, ensure the strainer baskets and screens installed in the piping systems permanent strainers are replaced with clean elements. Keep temporary strainers in service until the equipment has been tested, then replace straining element with a new strainer and clean and deliver the old straining elements to Owner. Fit the Owner's strainers with a line size blowoff valve.
  - 4. Install bypass piping or hoses at the supply and return piping connections at heat exchangers, chillers, cooling towers, pumps, and cooling coils, etc., to prevent debris from being caught or causing damage to equipment which will be connected to the piping system.
  - 5. Circulate a chemical cleaner in heating water piping systems to remove mill scale, grease, oil, and silt. Cleaner to be selected by chemical treatment vendor on project. Circulate for 48 hours, flush system and replace with clean water. Dispose of chemical solution in accordance with local codes. The heating water system should then be treated with chemicals and inhibitors to be selected by chemical treatment vendor on project. When the chemical cleaning is complete, remove, clean, and reinstall all permanent screens. Notify Owner so that the reinstallation of clean strainer screens may be witnessed.

### 3.02 REFRIGERANT PIPING INSTALLATION

- A. Install systems in accordance with ASHRAE Standard 15.
- B. Group piping whenever practical at common elevations and locations. Slope piping one percent in direction of oil return.
- C. 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.
- D. Flood piping system with nitrogen when brazing.
- E. Follow ASHRAE Standard 15 procedures for charging and purging of systems and for disposal of refrigerant.
- F. Provide replaceable cartridge filter-driers, with isolation valves and valved bypass.
- G. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.
- H. Fully charge completed system with refrigerant after testing.
- I. Field Quality Control:
  - 1. Test refrigeration system in accordance with ASME B31.5.



2. 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.

**END OF SECTION**



**SECTION 23 31 00**  
**HVAC DUCTS AND CASINGS**

**PART 1 - GENERAL****1.01 SUMMARY**

- A. Work Included:
  - 1. Ductwork, Joints and Fittings
  - 2. Insulated Flexible Duct
  - 3. Drain Pans
  - 4. Ductwork Joint Sealers and Sealants

**1.02 RELATED SECTIONS**

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.
- B. In addition, reference the following:
  - 1. Section 23 05 29, Hangers and Supports for HVAC Piping, Ductwork and Equipment.
  - 2. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

**1.03 REFERENCES AND STANDARDS**

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

**1.04 SUBMITTALS**

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
  - 1. Welding Certificates
  - 2. Field Quality Control Reports

**1.05 QUALITY ASSURANCE**

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
  - 1. NFPA Compliance:
    - a. NFPA 90A Installation of Air Conditioning and Ventilating Systems.
    - b. NFPA 90B, Installation of Warm Air Heating and Air Conditioning Systems.
  - 2. Comply with NFPA 96, Ventilation Control and Fire Protection of Commercial Cooking Operations, Ch. 3, Duct System for range hood ducts, unless otherwise indicated.
  - 3. Comply with SMACNA's HVAC Duct Construction Standards - Metal and Flexible for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Provide sheet metal materials free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
  - 4. If required, provide ductwork pressure testing per Section 23 05 93, Testing, Adjusting and Balancing for HVAC.

**1.06 WARRANTY**

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

**1.07 SYSTEM DESCRIPTION**

- A. Duct system design, as indicated, has been used to select size and type of air-moving and distribution equipment and other air system components. Duct design is generally diagrammatic and is not meant to be scaled. Major changes to layout or configuration of duct system must be specifically approved in writing by Architect. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

**PART 2 - PRODUCTS****2.01 MANUFACTURERS**

- A. Ductwork, Joints, and Fittings:
  - 1. Ductmate
  - 2. Lindab Inc
  - 3. Nexus Inc
  - 4. SEMCO
  - 5. United McGill Corporation
  - 6. Ward Industries
  - 7. Or approved equivalent
- B. Insulated Flexible Duct:
  - 1. ATCO
  - 2. Flexmaster
  - 3. J.P. Lamborn Co.
  - 4. Hart and Cooley
  - 5. Or approved equivalent
- C. Ductwork Joint Sealers and Sealants
  - 1. Ductmate
  - 2. Durodyne
  - 3. Hardcast
  - 4. United McGill Corporation
  - 5. Vulkern
  - 6. Foster
  - 7. Childer
  - 8. Or approved equivalent

**2.02 DUCTWORK, JOINTS AND FITTINGS**

- A. Materials:
  - 1. Galvanized Steel Ducts: Hot-dipped galvanized steel sheet, lock-forming quality, ASTM A 653/A 653M FS Type B, with G90/Z275 coating. Ducts to have mill phosphatized finish for surfaces exposed to view.
- B. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's HVAC Duct Construction Standards - Metal and Flexible and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
  - 1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
  - 2. Deflection: Duct systems not-to-exceed deflection limits according to SMACNA's HVAC Duct Construction Standards - Metal and Flexible.
  - 3. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.
- C. Formed-On Flanges: construct according to SMACNA's HVAC Duct Construction Standards - Metal and Flexible, Figure 1-4, using corner, bolt, cleat, and gasket details.
  - 1. Duct Size: Maximum 30-inches wide and up to 2-inch wg pressure class.
  - 2. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.
  - 3. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19-inches and larger and 0.0359-inch thick or less, with more than 10 SF of nonbraced panel area unless ducts are lined.
- D. Round, Spiral Lock-Seam Ducts: Fabricate supply ducts of material specified in this Section according to SMACNA's HVAC Duct Construction Standards - Metal and Flexible.

1. Ducts up to 20-inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
  2. Ducts 21- to 72-inches in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
  3. Ducts Larger than 72-inches in Diameter: Companion angle flanged joints per SMACNA HVAC Duct Construction Standards-Metal and Flexible, Figure 3-2.
  4. Round Ducts: Prefabricated connection system consisting of double-lipped, EPDM rubber gasket. Manufacture ducts according to connection system manufacturer's tolerances.
- E. 90-Degree Tees and laterals and Conical Tees: Fabricate to comply with SMACNA's HVAC Duct Construction Standards-Metal and Flexible, with metal thicknesses specified for longitudinal-seam straight ducts.
- F. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.
- G. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows to be 1.5 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:
1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's HVAC Duct Construction Standards-Metal and flexible, unless otherwise indicated.
  2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2- to plus 2-inch wg (minus 500 to plus 500 Pa):
    - a. Ducts 3- to 36-inches in Diameter: 0.034-inch .
    - b. Ducts 37- to 50-inches in Diameter: 0.040-inch.
    - c. Ducts 52- to 60-inches in Diameter: 0.052-inch.
    - d. Ducts 62- to 84-inches in diameter: 0.064-inch.
  3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch wg:
    - a. Ducts 3- to 26-inches in Diameter: 0.034-inch.
    - b. Ducts 27- to 50-inches in Diameter: 0.040-inch.
    - c. Ducts 52- to 60-inches in Diameter: 0.052-inch.
    - d. Ducts 62- to 84-inches in Diameter: 0.064-inch.
  4. 90-Degree, Two-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.
  5. Round Elbows
    - a. 8-inches and Less in Diameter: Fabricate die-formed elbows for 45 and 90-degree elbows and pleated elbows for 30, 45, 60 and 90 degrees only. Fabricate nonstandard bend-angle configurations or non-standard diameter elbows with gored construction.
    - b. 9 through 14-inches in Diameter: Fabricate gored or pleated elbows for 30, 45, 60 and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
    - c. Larger than 14-inches in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.
  6. Die-Formed Elbows for Sizes through 8-inches in Diameter and Pressures 0.040-inch thick with two-piece welded construction.
  7. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.
  8. Pleated Elbows for Sizes through 14-inches in Diameter and Pressures through 10-inch wg (2500 Pa): 0.022-inch.
  9. Not acceptable:
    - a. Corrugated or flexible metal duct.
    - b. Adjustable elbows.

**2.03 INSULATED FLEXIBLE DUCT**

- A. Construction: Standard factory fabricated product. Inner wall: Impervious vinyl or chlorinated polyethylene, permanently bonded to a vinyl or zinc-coated spring steel helix.
- B. Insulation: Fiberglass blanket insulation covered by an outer wall of vinyl or fiberglass-reinforced metalized vapor barrier.
- C. Listing: UL 181 listed Class 1 flexible air duct material. Overall thermal transmission: No more than 0.25 BTU/in or hr/sq. degrees F at 75 degrees F differential, per ASTM C335.
- D. Vapor transmission value no more than 0.10 perm, per ASTM E96
- E. Pressure Rating: 4-inch wg positive pressure and 1-inch wg negative pressure.
- F. Performance Air Friction Correction Factor: 1.3 maximum at 95 percent extension. Working air velocity: Minimum 2000 FPM.
- G. Flame Spread Rating: No more than 25.
- H. Smoke Development Rating: No more than 50 as tested per ASTM E84.
- I. Insertion Loss: Minimum attenuation of 29 DB for 10-foot straight length at 8-inch diameter at 500 Hz.

**2.04 DRAIN PANS**

- A. Primary Drain Pans: Stainless Steel, Fabricated in accordance with ASTM A167 and A480.
- B. Secondary Drain Pans: Galvanized Steel: Hot-dipped galvanized steel sheet, ASTM A 653/A 653M FS Type B, with G90/Z275 coating.

**2.05 DUCTWORK JOINT SEALERS AND SEALANTS**

- A. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
- B. Low Emitting Materials Requirement: Adhesives, sealants and sealant primers must comply with South Coast Air Quality Management District (SCAQMD) Rule #1168.
- C. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure and leakage class of ducts.
- D. Surface Burning Characteristics: Flame spread of zero, smoke developed of zero, when tested in accordance with ASTM E 84.
- E. Water Based Sealant for Brush-On Application: Flexible, adhesive sealant, resistant to UV light, UL-181A, and UL-181-B listed, complying with NFPA requirements for Class 1 ducts. Min. 69 percent solids, nonflammable. Hardcast Versa-Grip 181; Childers CP-146; Foster 32-19 for SMACNA 1/2, 1, 2, 3, 4, 6, and 10-inch WG duct classes, and SMACNA Seal Class A, B, or C.
- F. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C920, Type S, Grade NS, Class 25, Use O.
- G. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.
- H. Polyurethane Sealant: General-purpose, exterior use, non-brittle sealant for gunned application. Vulkem 616 or equal.

**PART 3 - EXECUTION****3.01 GENERAL INSTALLATION REQUIREMENTS**

- A. General: Use the following pressure class(es) in design of ductwork specified in this section unless otherwise noted on Drawings.

SYSTEM	PRESSURE IP (inches of water)	LEAKAGE CLASS
Low pressure supply (downstream of terminal unit)	+ 1-inch	C

Return main (>24-inch)	0.5-inch more negative than return/exhaust fan pressure or -2-inch pressure class, whichever is more negative.	A
Return branch (<24-inch)	0.5-inch more negative than return/exhaust fan pressure or -2-inch pressure class, whichever is more negative.	B, up to -3-inch wg. A, more negative than -3-inch wg.
General exhaust	0.5-inch more negative than return/exhaust fan pressure or -2-inch pressure class, whichever is more negative.	B, up to -3-inch wg. A, more negative than -3-inch wg.

**B. Ductwork Installation:**

1. **General:** Install entire duct system in accordance with drawings, Specifications, and latest issues of local Mechanical Code, NFPA 90A, and SMACNA Duct Construction Manual. At Contractor's option, rectangular ductwork may be resized to maintain an equivalent air velocity and friction rate, while maintaining a maximum aspect ratio of 3. Remove markings and tagging from ductwork exterior surface in mechanical rooms and other locations where ductwork is exposed.
2. The duct layout shown on the Contract Drawings is diagrammatic in nature. Coordinate the ductwork routing and layout, and make alterations to the ductwork routing and layout to eliminate physical interferences. Where deviations in the ductwork routing as shown in the Contract Drawings are required, alterations may be made so as not to compromise the air flow, pressure drop, and sound characteristics of the duct fitting or duct run as shown on the Contract Drawings. In the event Architect determines that the installed ductwork is inconsistent with the above mentioned criteria, remove and replace at no additional cost to the Owner.
3. Install ducts with fewest possible joints.
4. Install fabricated fittings for changes in directions, size, shape, and for connections.
5. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12-inches, with a minimum of 3 screws in each coupling.
6. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.
7. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
8. Install ducts with a clearance of 1-inch, plus allowance for insulation thickness. Allow for easy removal of ceiling tile.
9. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.
10. Coordinate layout with suspended ceiling, air duct accessories, lighting layouts, and similar finish work.
11. **Electrical and IT Equipment Spaces:** route ducts to avoid passing through transformer vaults, electrical equipment spaces, IDF/MPOE rooms, and enclosures.
12. **Boiler Rooms and Refrigeration Machinery Rooms:** Only route ducts serving these rooms through these rooms.
13. **Non-Fire-Rated Partition Penetrations:** Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2-inches.
14. **Fire- and Smoke-Rated Partition Penetrations:** Where ducts pass through interior partitions and exterior walls, install appropriately rated fire, smoke or combination fire and smoke dampers as governed by Building Code and AHJ, including sleeves, and firestopping sealant.

15. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes. Reference SMACNA's Seismic Restraint Manual: Guidelines for Mechanical Systems, Mason Seismic Restraint and Support Systems.
  16. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's Duct Cleanliness for New Construction Advanced Level.
  17. Paint interiors of metal ducts, that do not have duct liner, for 24-inches upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible duct material.
  18. Install ductwork in the location and manner shown and detailed. Review deviations required by job conditions with Architect prior to any fabrication. Provide fittings for construction per SMACNA.
- C. Flanged Take-Offs:
1. Install at branch takeoffs to outlets using round or flex duct.
  2. Flanged take-offs secured with minimum 8-inch screw spacing (three screws minimum).
  3. Provide ductwork taps and branches off of main ducts at 45 degrees whether shown on Drawings or not (drawings are diagrammatic).
- D. Cleaning:
1. Clean duct systems with high power vacuum machines. Protect equipment that could be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes.
  2. Grille and Exposed Duct Cleaning:
    - a. After completion of ductwork installation, operate each fan system (excluding exhaust fans) for a minimum of 30 minutes prior to installation of ceiling grilles and diffusers. After grilles and diffusers are installed, clean out accumulation of particles from grilles and diffusers prior to acceptance.
    - b. Clean exterior surface of ducts exposed to public view of chalk, pencil and pen marks, labels, sizing tags, dirt, dust, etc., so that upon completion of installation, ducts are left in clean and unblemished manufactured conditions.
    - c. Exposed duct and grilles to remain free of dust entrained streaks due to leakage at joints and grille connections during warranty period. Clean leaks, seal and refinish to match existing if visible streaks develop.

### 3.02 DUCTWORK, JOINTS AND FITTINGS INSTALLATION

A. Duct Materials - Applied Locations:

1. General: Use the following materials in design of ductwork specified in this Section unless otherwise noted on the Drawings.

Location or Application	Material
Supply, Return, Transfer, and Exhaust - Low Pressure (downstream of terminal units)	Single Wall, Galvanized Steel
Supply, Return, and Exhaust - Medium Pressure (upstream of terminal units)	Single Wall, Galvanized Steel
General Exhaust Branch Serving Air Inlet in Shower Room or Toilet Room with Shower	Single Wall, Aluminum or Type 304 Stainless Steel

B. Ductwork Installation:

1. Fabricate radius elbows with centerline radius not less than 1-1/2 duct diameters.
2. Do not install duct size transition pitch angles which exceed 30 degrees for reductions in duct size in the direction of airflow, and 15 degrees for expansions in duct size in the direction of airflow.
3. Install fixed turning vanes in square throat rectangular elbows and in tees.
4. Fabricate duct turns with the inside (smallest) radius at least equal to the duct width (supply ducts) and 1.5 times radius (return and exhaust ducts). Where necessary, square



elbows may be used, with maximum available inside radius and with fixed turning vanes. In healthcare settings such as hospitals and medical office buildings, square elbows and turning vanes allowed on supply ductwork only.

### **3.03 INSULATED FLEXIBLE DUCT INSTALLATION**

- A. Provide sheet metal plenum or rigid elbow and connect to diffusers and grilles with ductwork connections. Refer to Drawings for more information. Provide straight section of flexible duct with minimum length of 2-feet and maximum length of 5-feet and connect to sheet metal plenums and rigid elbows connected to diffusers and grilles, unless noted otherwise.
  - 1. Provide round neck grilles/diffusers or square-to-round transitions. Flexible duct connections directly to diffuser and grilles is not allowed.
  - 2. Flexible duct allowed in concealed spaces above lay-in ceilings only.

### **3.04 DRAIN PANS INSTALLATION**

- A. Install where shown on Drawings. Drain provided by Division 22, Plumbing. Provide drain (sized per code) connection from each drain pan and pipe to nearest floor drain through trap and 10-inch air gap. Drain pans over 6-feet in length require drain connections from both ends. Pitch drain pans in direction of air flow and to drain. Support secondary drain pan independently from equipment.

### **3.05 DUCTWORK JOINT SEALERS AND SEALANTS INSTALLATION**

- A. Joints and Seam Joint Sealing:
  - 1. Seal duct seams and joints according to SMACNA's HVAC Duct Construction Standards - Metal and Flexible for duct pressure class indicated.
  - 2. For 1/2- and 1-inch wg pressure classes, seal transverse joints.
  - 3. For 2- and 3-inch wg pressure classes, seal transverse joints and longitudinal seams.
  - 4. For pressure classes more than 3-inch wg, seal transverse joints, longitudinal seams and duct wall penetrations including screw, fastener, pipe, rod, and wire.
  - 5. Seal ducts before external insulation is applied.
  - 6. Tape joints of PVC coated metal ductwork with PVC tape.
  - 7. Fasteners such as sheet-metal screws, machine screws or rivets to be cadmium plated.
  - 8. Rectangular Ductwork: Where intermediate joint reinforcement is required for duct of negative pressure class, pre-drill stiffening flange and provide fastener maximum 8-inches on center. Where retaining flanges are welded to duct wall, paint welds with zinc coating.
  - 9. Single Wall Round Ductwork: Joint to incorporate beaded slip collar with minimum #8 sheet metal screws 8-inches on center. Seal ductwork as specified in this Section.
  - 10. Seal joints and seams. Apply sealant to make end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
  - 11. Double Wall Round Ductwork: Joint to incorporate beaded slip collar or flanged connection, with minimum #8 sheet metal screws 8-inches on center. Seal ductwork as specified in this Section.
  - 12. Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.
  - 13. Provide openings in ductwork where required to accommodate thermometers and control devices. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
  - 14. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities as well as Code required clearances.

### **END OF SECTION**



**SECTION 23 33 00**  
**AIR DUCT ACCESSORIES**

**PART 1 - GENERAL****1.01 SUMMARY**

- A. Work Included:
  - 1. Sheet Metal Materials
  - 2. Backdraft Dampers
  - 3. Dampers
  - 4. Concealed Damper Hardware
  - 5. Access Doors
  - 6. Duct Test Holes
  - 7. Flexible Connectors

**1.02 RELATED SECTIONS**

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

**1.03 REFERENCES AND STANDARDS**

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

**1.04 SUBMITTALS**

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
  - 1. Manufacturer's catalog data and fabrication/installation drawings for each factory fabricated duct accessory. Include leakage, pressure drop and maximum back pressure data.
  - 2. Shop Drawings: Indicate air duct accessories.
  - 3. Manufacturer's installation instructions: Provide instructions for each factory fabricated duct accessory.
  - 4. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
    - a. See Division 01, General Requirements, Product Requirements for additional provisions.
    - b. Extra Fusible Links: One of each type and size.

**1.05 QUALITY ASSURANCE**

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
  - 1. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this Section, with minimum five years of documented experience.
  - 2. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
  - 3. AMCA 500 - Test Methods for Louvers, Dampers and Shutters.
  - 4. AMCA 511 - Certified Ratings Program for Air Control Devices.
  - 5. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
  - 6. NFPA 92A - Smoke-Control Systems.
  - 7. NFPA 92B - Smoke Control Systems in Atria, Covered Malls and Large Areas.
  - 8. NFPA 101 - Life Safety Code.
  - 9. UL 555 - Standard for Safety; Fire Dampers.
  - 10. UL 555S - Standard for Safety; Leakage Rated Dampers for Use in Smoke Control Systems.

**1.06 WARRANTY**

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

**PART 2 - PRODUCTS****2.01 MANUFACTURERS**

- A. Backdraft Dampers:
  - 1. Air Balance
  - 2. Cesco
  - 3. Greenheck
  - 4. Nailor
  - 5. Ruskin
  - 6. Or approved equivalent.
- B. Dampers:
  - 1. Air Balance
  - 2. Cesco
  - 3. Greenheck
  - 4. Nailor
  - 5. Ruskin
  - 6. Or approved equivalent.
- C. Concealed Damper Hardware, Cable System:
  - 1. Young Regulator Company
  - 2. Or approved equivalent.
- D. Access Doors:
  - 1. Ductmate
  - 2. Cesco
  - 3. Ruskin
  - 4. Nailor
  - 5. Outdoor Installation: Karp MX insulated exterior access door.
  - 6. Or approved equivalent.
- E. Duct Test Holes:
  - 1. Ventlok
  - 2. Or approved equivalent.
- F. Flexible Connectors:
  - 1. Duro Dyne Corp.
  - 2. Ventfabrics Inc.
  - 3. Ward Industries
  - 4. Or approved equivalent.

**2.02 SHEET METAL MATERIALS**

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M. Galvanizing: 1-1/4 ounces per square foot total both sides; ducts to have mill-phosphatized finish for surfaces exposed to view.
- C. Stainless Steel: ASTM A 480/A 480M.
- D. Aluminum Sheets: 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.
- E. Extruded Aluminum: ASTM B 221 (ASTM B 221M), alloy 6063, temper T6.

- F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36-inches or less; 3/8-inch minimum diameter for lengths longer than 36-inches.

### **2.03 BACKDRAFT DAMPERS**

- A. Basis-of-Design: Ruskin CB D6.
- B. Description: Multiple-blade gravity balanced with center pivoted blades with sealed edges, assembled in rattle free manner with 90-degree stop, adjustment device to permit setting for varying differential static pressure.
- C. Frame: 0.125-inch thick 6063-T5 extruded aluminum channel with galvanized steel braces at mitered corners. Provide mounting flange.
- D. Blades: Single piece, overlap frame, parallel action, horizontal orientation, minimum 0.07-inch 6063-T5 extruded aluminum material, maximum 6-inch width.
- E. Bearings: Corrosion-resistant synthetic, formed as single piece with axles.
- F. Blade Seals: Extruded vinyl, mechanically attached to blade edge.
- G. Blade Axles: Corrosion-resistant, synthetic formed as single piece with bearings, locked to blade.
- H. Tie Bars and Brackets: Galvanized steel.
- I. Return Spring: Adjustable tension.
- J. Damper Capacity:
  - 1. Closed Position: Maximum back pressure of 16-inches water gauge.
  - 2. Open Position: Maximum air velocity of 2,500-feet per minute.
- K. Counterbalances: Adjustable zinc plated steel weights mechanically attached to blade. Must be capable of operating over wide range of pressures.
- L. Finish: Mill aluminum.
- M. Temperature Rating: -40 degrees F to 200 degrees F.
- N. Operation of Blade:
  - 1. Start to Open: 0.01-inch wg
  - 2. Fully Open: 0.05-inch.
- O. Pressure Drop: Maximum 0.15-inch wg at 1,500-feet per minute through 24-inch by 24-inch damper.
- P. Factory Sleeve: Minimum 20 gauge thickness, 12-inches in length.
- Q. Screen: At outdoor intake or discharge. 1/4-inch aluminum.

### **2.04 DAMPERS**

- A. Basis-of-Design: Ruskin MD 35.
- B. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.
  - 1. Pressure Classes of 3-Inch wg (750 Pa) or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.
- C. Rectangular Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design with linkage concealed in frame and suitable for horizontal or vertical applications.
  - 1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum 16 gauge thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
    - a. Roll-Formed Steel Blades: 16 gauge thick, galvanized sheet steel.

- b. Aluminum Frames: Hat-shaped, 10 gauge thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
  - c. Roll-Formed Aluminum Blades: 10 gauge thick aluminum sheet.
  - d. Extruded-Aluminum Blades: 16 gauge thick extruded aluminum.
  - e. Blade Axles: Minimum 1/2-inch diameter, plated steel, hex shaped, mechanically attached to blade.
  - f. Bearings: Molded synthetic sleeve, turning in extruded hole in frame.
  - g. Tie Bars and Brackets: Galvanized steel.
  - h. Mill galvanized.
  - i. Capacity:
    - 1) Closed Position: Maximum pressure of 3-inches wg.
    - 2) Open Position: Maximum air velocity of 1,500-feet per minute across 24-inch by 24-inch damper.
- D. Round Volume Dampers: Single-blade suitable for horizontal or vertical applications.
- 1. Steel Frames: Galvanized, roll formed, minimum of 20 gauge thick with beads at each end.
  - 2. Blades: Minimum 20 gauge thick, galvanized sheet steel, round, single-piece.
  - 3. Aluminum Frames: Minimum 10 gauge thick aluminum sheet.
  - 4. Aluminum Blades: Minimum 10 gauge thick aluminum sheet.
  - 5. Extruded-Aluminum Blades: Minimum 16 gauge thick extruded aluminum.
  - 6. Blade Axles: Minimum 3/8-inch square, plated steel, mechanically attached to blade.
  - 7. Bearings: Molded synthetic sleeve, turning in hole in frame.
  - 8. Finish: Mill galvanized.
  - 9. Capacity:
    - a. Closed Position: Maximum pressure of 3-inches wg
    - b. Open Position: Maximum air velocity of 1,500-feet per minute.
  - 10. Leakage: Maximum 40 cfm at 1-inch wg for 20-inches diameter damper.
  - 11. Pressure Drop: Maximum 0.02-inch wg at 1,500-feet per minute through 20-inch diameter dampers.
- E. Jackshaft: 1-inch diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
- 1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.
  - 2. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include 2-inch elevated platform for insulated duct mounting.

## **2.05 CONCEALED DAMPER HARDWARE**

- A. Concealed Damper Hardware: For dampers above non-removable ceilings (gyp, plaster, decorative, etc.) where access panels have not been shown on Architectural drawings or in locations where dampers are more than 2-feet above the ceiling, provide:
- 1. Concealed Damper Regulator: Young Regulator Company Model 315 or approved equivalent.
  - 2. Cable System: Young Regulator Company or approved equivalent.
  - 3. Controller: Young Regulator Company 270-275 or approved equivalent.
  - 4. Control wrenches, wire stops, casing nuts, and stainless steel wire.
  - 5. Paint cover plate to match ceiling color or as directed by Architect.

## **2.06 ACCESS DOORS**

- A. Duct Pressure Class 2-inch WC and Greater: Sandwich-type design with threaded locking bolt assembly. Closed cell neoprene gasket permanently bonded to inside panel. Zinc-coated steel wing nuts or polypropylene molded knobs with threaded metal inserts - zinc coated bolts sealed to inner panel.

- B. Duct Pressure Class 1-1/2-inch WC and Less: Galvanized steel assembly incorporating frame, door, hinges, and latch(es). Frame tabbed for attachment to duct panel. Double wall door panel with 1-inch insulation. Open cell neoprene gasket attached to frame. Cam latches for tight closure.
- C. Plenum Doors: Extruded aluminum frames with extruded santoprene seals. Double-wall 20 gauge galvanized steel door panel with fiberglass insulation.
- D. Size: Maximum size available to fit rectangular duct panel dimension or round duct diameter. Plenum doors minimum 2-feet wide by 4-feet high.
- E. For outdoor installation, only provide waterproof access doors installed vertically.

## **2.07 DUCT TEST HOLES**

- A. Temporary Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.
- B. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

## **2.08 FLEXIBLE CONNECTORS**

- A. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
- B. Metal-Edged Connectors: Factory fabricated with a fabric strip 4-inches wide attached to two strips of 2-3/4-inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Select metal compatible with ducts.
- C. Indoor System, Flexible Connector Fabric (FC-I): Glass fabric double coated with neoprene.
  - 1. Minimum Weight: 26 ounces per square yard.
  - 2. Tensile Strength: 480 pounds of force per in the warp and 360 pounds of force per inch in the filling.
  - 3. Service Temperature: -40 degrees F to 200 degrees F.

## **PART 3 - EXECUTION**

### **3.01 DUCT ACCESSORIES GENERAL INSTALLATION**

- A. Inspect areas to receive air duct accessories. Notify Engineer of conditions that would adversely affect the installation of the dampers. Do not proceed until conditions are corrected.
- B. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts.
- C. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- D. Do not compress or stretch damper frames into duct or opening.
- E. Handle dampers using sleeve or frame. Do not lift dampers using blades, actuators, or jack shafts.
- F. Adjust duct accessories for proper settings.

### **3.02 SHEET METAL MATERIALS INSTALLATION**

- A. Install bracing for multiple sections to support assembly weights and hold against system pressure. Install bracing as needed.

### **3.03 BACKDRAFT DAMPERS INSTALLATION**

- A. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated. Provide at outside air intakes where motorized dampers are not shown on drawings.

### **3.04 DAMPERS INSTALLATION**

- A. Where installing volume dampers in ducts with liner, avoid damage to and erosion of duct liner.

- B. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts for air balancing. Install at a minimum of two duct widths from each branch takeoff. Provide balancing dampers for all air inlets and outlets.
- C. Install dampers square and free from racking with blade running horizontally.

### **3.05 CONCEALED DAMPER HARDWARE INSTALLATION**

- A. Coordinate location in Reflected Ceiling Plan and color of concealed damper hardware with Architect prior to installation.

### **3.06 ACCESS DOORS INSTALLATION**

- A. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:
  - 1. On both sides of duct coils.
  - 2. Downstream from volume dampers, turning vanes and equipment.
  - 3. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
  - 4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot (15-m) spacing.
  - 5. Install the following sizes for duct-mounting, rectangular access doors:
    - a. One-Hand or Inspection Access: 8-inches by 5-inches.
    - b. Two-Hand Access: 12-inches by 6-inches.
    - c. Head and Hand Access: 18-inches by 10-inches.
    - d. Head and Shoulders Access: 21-inches by 14-inches.
    - e. Body Access: 25-inches by 14-inches.
    - f. Body Plus Ladder Access: 25-inches by 17-inches.
  - 6. Install the following sizes for duct-mounting, round access doors:
    - a. One-Hand or Inspection Access: 8-inches in diameter.
    - b. Two-Hand Access: 10-inches in diameter.
    - c. Head and Hand Access: 12-inches in diameter.
    - d. Head and Shoulders Access: 18-inches in diameter.
    - e. Body Access: 24-inches in diameter.
  - 7. Label access doors.

### **3.07 DUCT TEST HOLES INSTALLATION**

- A. Provide test holes at fan inlets and outlets where indicated and where required for air testing and balancing.

### **3.08 FLEXIBLE CONNECTORS INSTALLATION**

- A. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators. Provide sheet metal weather cover over flexible connections located outdoors. Attach sheet metal to either equipment side or ductwork side, but not both.
- B. Per NFPA, do not use flexible connectors on grease exhaust fans
- C. For fans developing static pressures of 5-inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- D. Adjust the following types in the following locations:
  - 1. FC-I: Indoors.

**END OF SECTION**



**SECTION 23 37 00**  
**AIR OUTLETS AND INLETS**

**PART 1 - GENERAL****1.01 SUMMARY**

- A. Work Included:
  - 1. Grilles, Registers, Diffusers

**1.02 RELATED SECTIONS**

- A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

**1.03 REFERENCES AND STANDARDS**

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

**1.04 SUBMITTALS**

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, provide:
  - 1. Data Sheet: For each type of air outlet and inlet, and accessory furnished; indicate construction, finish, and mounting details.
  - 2. Performance Data: Include throw and drop, static-pressure drop, and noise ratings for each type of air outlet and inlet.
  - 3. Schedule of diffusers, registers, and grilles indicating drawing designation, room location, quantity, model number, size and accessories furnished.

**1.05 QUALITY ASSURANCE**

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.
- B. In addition, meet the following:
  - 1. Air Distribution Diffuser, Register, and Grille Schedule lists Basis of Design, with any specialty accessories, construction, finish or other criteria noted on schedule. Submitted air distribution must match criteria of Basis of Design:
    - a. Construction materials and appearance.
    - b. Frame/installation method.
    - c. Isothermal throw plus or minus 5 percent at design flows shown on drawings.
    - d. Noise Criteria: NC value plus or minus 1 at design flows shown on drawings.
    - e. Accessories: Equal to Basis of Design.

**1.06 WARRANTY**

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

**PART 2 - PRODUCTS****2.01 MANUFACTURERS**

- A. General: Manufacturer's standard products of categories and types required for each application as referenced in other Division 23, HVAC sections, where more than a single type is specified for the application, provide single selection for each product category.
- B. Grilles, Registers, Diffusers:
  - 1. Anemostat
  - 2. Carnes
  - 3. Environmental Air Products
  - 4. Kruger
  - 5. Metalaire
  - 6. Nailor

7. Price Co.
8. Shoemaker
9. Titus
10. Tuttle & Bailey
11. Seiho
12. Or approved equivalent.

## **2.02 GRILLES, REGISTERS, DIFFUSERS**

- A. Diffuser, Register and Grille Schedule lists Basis of Design, with specialty accessories, construction, finish or other criteria noted on schedule. Submitted air distribution must match criteria of Basis of Design, including accessories and finish:
  1. Matching construction materials and appearance. Equal installation method/frame.
  2. Pressure drop equal to or less than Basis of Design at CFM on Drawings.
  3. Throw: Isothermal jet throw plus or minus 5 percent of Basis of Design at CFM listed on Drawings.
  4. Noise Criteria: Plus or minus 1 NC of Basis of Design at CFM listed on Drawings. If Basis of Design NC is below registered level, submitted must match. NC rating with 10 dB room factor or less.
- B. Provide 1-, 2-, 3-, or 4-way deflection as indicated on Drawings.
- C. Provide pattern controllers for linear supply air diffusers.
- D. Register Dampers: Dampers utilized with grilles. Opposed blade dampers utilizing a side operated worm drive which provides external duct operation. Slot the end of the shaft to receive a screwdriver. Factory assembled side operator. Construct of the same material as the grille. Manufacturer same as grilles/diffuser.
- E. Coordinate mounting frames with ceiling construction type. Verify per reflected ceiling plans.

## **PART 3 - EXECUTION**

### **3.01 GENERAL INSTALLATION**

- A. Install in accordance with manufacturer's instructions. Provide seismic supports, clips, and bracing per local code. Coordinate installation of framing. Provide complete coverage of rough openings by integral device flanges or auxiliary frames. Where above ceiling location is unconditioned space, caulk rough openings; repair and re-paint locations where dust entrainment streaks develop due to unsealed openings.
- B. Damp locations, such as lockers, restrooms, showers, natatoriums, whirlpool/spas, to have aluminum construction even if scheduled otherwise; mounting hardware to be stainless steel.
- C. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
- D. Unless otherwise shown on drawings, for ceiling mounted air outlets with adjustable airflow pattern controllers mounted at a height of 12 feet or less, adjust the air outlets for horizontal air distribution, and adjust to vertical air distribution for ceiling height above 12 feet.
- E. Exterior color of grilles per Architect. White finish if not otherwise scheduled or noted by Architect. Paint ductwork visible behind air outlets and inlets matte black.
- F. Ceiling Membrane: Protect ceiling membrane per code. Fire caulk around openings. Provide listed radiation damper in rated roof/ceiling or floor/ceiling assemblies as required per code.
- G. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove burrs, dirt, and smudges. Replace diffusers, registers, and grilles that have damaged finishes.

### **3.02 GRILLES, REGISTERS AND DIFFUSERS INSTALLATION**

- A. Coordinate with Architectural Reflected Ceiling Plan(s). Reflected ceiling plans determine final locations.

- B. Install diffusers to ductwork with air tight connection. 18-inch straight duct section or acoustic plenum at connection. Provide square to round adapters where required for connection to round ducts.
- C. Provide integral balancing dampers for diffusers, and grilles and registers where duct manual balancing dampers are not shown or specified.
- D. Linear Slot Diffusers:
  - 1. Coordinate connection plenum dimensions with linear slot final dimensions to conform with manufacturer's recommendations, or as indicated. Total and active lengths as noted on drawings. Blank off unused sections. Coordinate frame type with Architect.
  - 2. Paint surfaces visible behind air outlets and inlets, including blank-off sections, matte black unless otherwise called for on drawings.

**END OF SECTION**



**SECTION 23 81 26****SMALL SPLIT SYSTEM AND UNITARY HVAC EQUIPMENT****PART 1 - GENERAL****1.01 SUMMARY**

- A. Work Included: Materials, installation and testing of:
  - 1. Ductless Split Systems - Cooling Only

**1.02 RELATED SECTIONS**

- A. Contents of Section 23 00 00, HVAC Basic Requirements and Division 1, General Requirements apply to this Section.

**1.03 REFERENCES AND STANDARDS**

- A. References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 1, General Requirements.
- B. In addition, meet the following:
  - 1. ARI 210

**1.04 SUBMITTALS**

- A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 1, General Requirements.

**1.05 QUALITY ASSURANCE**

- A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 1, General Requirements.
- B. In addition, meet the following:
  - 1. Efficiency ratings, cooling/heating performance, fan performance, sound performance to meet or exceed Basis of Design as scheduled on Drawings.

**1.06 WARRANTY**

- A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 1, General Requirements.
- B. In addition, provide:
  - 1. Refrigeration compressor(s): 5-year warranty.
  - 2. Furnace heat exchanger: 5-year warranty.

**PART 2 - PRODUCTS****2.01 MANUFACTURERS**

- A. Ductless Split Systems:
  - 1. Mitsubishi
  - 2. Sanyo
  - 3. Daikin Applied
  - 4. LG
  - 5. Carrier
  - 6. Friederich
  - 7. Or approved equivalent.

**2.02 DUCTLESS SPLIT SYSTEMS - COOLING ONLY**

- A. Description: Self-contained, matched factory-engineered and assembled. Pre-wired indoor and outdoor units. UL/ETL listed.
- B. Outdoor Unit:
  - 1. Self contained, consisting of cabinet, compressor system, condenser fan matched to indoor unit.
  - 2. Cabinet: Fabricated of galvanized steel, bonderized, and finished with powder coated baked enamel.

3. Refrigerant System:
    - a. HFC refrigerant or other refrigerant with zero ozone depletion potential (ODP)
    - b. Compressor: To be inverter driven, hermetic rotary type.
  4. Air System:
    - a. Fan: Propeller Type with one direct drive, inverter driven, variable speed motor.
    - b. Motor: Premium efficiency with inherent protection, permanently lubricated bearings and variable speed drive compatible.
    - c. Coil: Copper tubes and aluminum fins .
  5. Controls: Single source for both indoor and outdoor units, with low/high pressure switch capable of communicating to/from the building DDC control system.
- C. Indoor Unit(s):
1. Self contained ceiling mounted evaporator unit(s) matched to outdoor unit.
  2. Cabinet:
    - a. Non-flammable, high impact polymer with a white finish.
    - b. Power Source: To be a single point power connection or sub-fed from outdoor condensing unit.
  3. Refrigeration System: HFC refrigerant or other refrigerant with zero ozone depletion potential (ODP).
  4. Air System:
    - a. Fan: An assembly with one or two inline fan(s) with a single direct drive motor.
    - b. Filter: Polypropylene, furnished with the unit, removable and washable.
    - c. Coil: Direct expansion type with copper tubes mechanically bonded into aluminum fins.
  5. Condensate Drain:
    - a. Provide drain pan sloped to drain away from unit. Drain pan with a single drain connection.
    - b. Condensate pump kit provided with unit.
    - c. Secondary drain pan; Condensate overflow shut-off float switch and external alarm.
  6. Controls: Wired thermostat. Control to be integral with unit.

## **PART 3 - EXECUTION**

### **3.01 GENERAL INSTALLATION REQUIREMENTS**

- A. Install with required clearances and access for maintenance.
- B. Install factory furnished devices for field installation.
- C. Inspect for and remove shipping bolts, blocks and tie-down straps.
- D. After energizing units: Test units for proper fan rotation. Test and adjust controls and internal safeties. Replace malfunctioning units and retest.
- E. Thoroughly clean exposed portions of equipment. Install new filters prior to final test and balance and again prior to final acceptance.

### **3.02 DUCTLESS SPLIT SYSTEMS - COOLING ONLY INSTALLATION**

- A. Condensate piped to indirect waste connection; cleanouts at changes of direction; sized and sloped to drain per Code. Secondary drain pan with float switch.

**END OF SECTION**