

SECTION 23 0100

OPERATION AND MAINTENANCE OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Service for heating, ventilating, and air conditioning equipment required for the work as indicated on the drawings, including the items listed in "Related Sections".

1.2 RELATED SECTIONS

- A. Operating manuals: Division 01 and Section 23 0101.
- B. General project warranty: General Conditions.
- C. Ductless split-system units: Section 23 8127.
- D. Air-source heat pump units: Section 23 8143.

1.3 DESIGN REQUIREMENTS

- A. The products specified, scheduled, and shown on drawings are the basis of the design of this project.
- B. For requirements affecting use of optional manufacturers, or substitutions, see Division 01 and Section 23 0101, HVAC General Provisions, and Section 23 0500, Common Work Results for HVAC.

1.4 SUBMITTALS

- A. Shop drawings:
 - 1. Refrigeration service organization: Name and address of proposed agency.
 - 2. Proposed service or test agreement of each type included in the project, showing conformance to specifications. Include detailed list of work to be performed at each visit.
- B. Certifications:
 - 1. Qualifications of refrigeration installation and service agency.
 - 2. Each installation and service organization: A list of at least ten projects, similar to this project in type, size, and components, which have been operating satisfactorily for at least two heating and cooling seasons.
 - 3. Include evidence of each requirement specified in the article below for qualifications of each service and maintenance agency.
- C. Field test reports: Test and inspection reports for refrigeration equipment.

1.5 QUALITY ASSURANCE

- A. Perform work in accordance with the plumbing, electrical, building, fire and safety codes of the state, county or city in which the work is performed.

- B. UL label and local testing (if required): As specified in Section 23 0500, Common Work Results for HVAC.
- C. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1 Energy Efficient Design of New Buildings Except Low-rise Residential Buildings.

1.6 QUALIFICATIONS OF EACH SERVICE AND MAINTENANCE AGENCY

- A. Regularly engaged in performing installation, startup, and service work for equipment and systems of the types included in this project.
- B. Located in the Baltimore/Washington, DC, metropolitan area.
- C. Staff factory-trained by the manufacturer of the equipment included in this project.
- D. Provides emergency service on call 24 hours a day.
- E. Maintains an adequate stock of manufacturer's genuine or approved parts to service this equipment.
- F. Has service contracts available, which can meet requirements specified for the equipment and systems of this project.

1.7 REFRIGERATION EQUIPMENT WARRANTY AND SERVICE

- A. Manufacturer's authorized and factory-trained startup and service organization will be responsible for starting, adjusting, and servicing the complete refrigeration system during the term of the correction period of this contract.
- B. Ascertain that piping installation, wiring, control installation, and appurtenances of each refrigeration unit are in accordance with the recommendations of the manufacturer. Upon initial startup, operate and adjust the unit to obtain the performance specified by the manufacturer.
- C. Special warranties shall cover the replacement of all parts and components for no less than the time of the general project correction period, starting from the date of substantial completion.
- D. Compressors shall have an additional extended parts-only warranty for a total of five years including the general correction period.
- E. Refrigerant circuits of self-contained units shall have an additional extended parts-only warranty for a total of five years including the general correction period.
- F. Supply emergency service promptly upon call during correction period with no extra charge to the Government.
- G. Maintenance in addition to repair: In addition to the repair service required during the correction period, provide maintenance by the manufacturer's authorized factory-trained local agent including a visit to the project near the end of the first full cooling season. The planned maintenance program shall include:
 - 1. Inspect complete refrigerant circuit for refrigerant leaks with approved halide or electronic leak detector.
 - 2. Replace defective parts and refrigerant at no addition to the contract sum.
 - 3. Tighten belts, nuts, screws, and terminal wiring connections as required.

4. Clean evaporator-condenser coils as needed.
5. Lubricate moving parts as needed.
6. Adjust, align, and replace belts where needed.
7. Check for oil or refrigerant leaks and correct as necessary.
8. Check for blockage of condensate elimination system and correct as required.
9. Check and record unit starting and running amperage.
10. Check and record power voltage and control voltage.
11. Check and record operating temperatures and pressure. (Pressure not required on hermetic circuits.)
12. Check and record thermostatic expansion valve super heat.
13. Check temperature and pressure controls and adjust as required.
14. Check for proper operation of limit switches and safety controls.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 ELECTRIC WIRING FOR MOTORS, STARTERS, AND CONTROLS

- A. Furnish and install and in most cases factory-wire motor starters specified under each technical section in this division. Furnish and install under Division 26 starters not specifically specified with equipment. Unless specified otherwise, automatic control devices for equipment are furnished with the equipment.
- B. Unless explicitly specified otherwise, mount and completely wire under Division 26 all starters and automatic control devices, except those which are factory-mounted on equipment.
- C. Unless specified otherwise, motor disconnects, manual starters, pushbutton stations, and pilot lights are specified in Division 26, Electrical. Equipment specified in Division 23 shall be suitable for operation in conjunction therewith.
- D. Unless specified otherwise in a particular section, electric motors shall comply with the requirements of Section 23 0513.

3.2 IDENTIFICATION

- A. Identify equipment as required in Section 23 0500, Common Work Results for HVAC.
- B. Thermometers, gauges, and control devices shall be identified.

3.3 TESTING MECHANICAL EQUIPMENT

- A. Check and adjust all heating and cooling equipment installed.
- B. Operate heating and cooling equipment and check controls including high and low limit controls.
- C. Mechanical equipment shall be proven to function properly by actual operation prior to final acceptance.

3.4 EQUIPMENT LUBRICATION

- A. Bearings of equipment shall be provided with adequate facilities for lubrication. Oiling devices shall be accessible. Lubricate bearings upon completion of work prior to startup of the equipment. Lubricants shall be as specified by equipment manufacturers.

END OF SECTION

SECTION 23 0101

HVAC GENERAL PROVISIONS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. General provisions and requirements for all HVAC work.

1.2 RELATED SECTIONS

- A. Requirements of this section generally supplement requirements of Division 01.

1.3 REFERENCES

- A. NFPA 10: Portable Fire Extinguishers.
- B. NFPA 241: Safeguarding Construction, Alteration, and Demolition Operations.

1.4 SYSTEM DESCRIPTION

- A. The full set of Contract Documents applies to work of Division 23.
- B. Visit the site and study all aspects of the project and working conditions, as required by General and Supplementary Conditions, Bidding and Contracting Requirements, Drawings, and Specifications. Verify field dimensions.
- C. The work covered in technical sections includes the furnishing of all labor, equipment and materials, and the performance of all operations pertinent to the work described.
- D. Except as required otherwise in Division 01, promptly obtain and pay for, including all necessary signatures and paperwork, all permits, fees and inspections required for work of this division by authorities having jurisdiction, including any utility connection or extension charge. No payment will be made until a copy of the permit is forwarded to the Government.
- E. HVAC work of this project includes, as a brief general description, the following:
 - 1. Removal of existing through wall air conditioning units and electric baseboard heaters
 - 2. Installation of a new split system heat pump unit and associated ductwork, air devices, and piping to serve the Registration Station.
 - 3. Installation of two new ductless split systems to serve the pay booths.
- F. See Division 01 for requirements related to Government's occupancy of the premises, limits on use of site, time restrictions on work, limits on utility outages or shutdowns, and phasing (sequencing) and scheduling.

1.5 PRODUCT OPTIONS

- A. Except as modified by provisions of Bidding and Contracting Requirements and Division 01, these options apply to Division 23 specifications.
- B. General: Where Contractor is permitted to use a product other than the specified item and model named as the basis of design, Contractor is responsible for all coordination and additional costs as specified in the article "Substitutions," below for substitutions.

- C. Products specified by reference standards or by description only: Any product meeting those standards or description.
- D. Products specified by naming one or more manufacturers, or model name or catalog reference number: Products specified establish a standard of quality, options to be included, and performance, and shall not be construed as limiting competition. Contractor may use products of any manufacturer, which meet the specifications.
- E. Products specified by naming one manufacturer and particular product, with no provision for other options: No options or substitutions allowed.

1.6 SUBSTITUTIONS

- A. Substitutions will be considered only as permitted or required by the Bidding and Contracting Requirements and Division 01. Except as modified by those requirements, the requirements below apply to Division 23 specifications.
- B. Substitutions may be considered when a product becomes unavailable through no fault of the Contractor.
- C. Document each request with complete data substantiating compliance of proposed substitution with contract documents.
- D. A request constitutes a representation that the Bidder or Contractor:
 - 1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.
 - 2. Will provide the same warranty for the substitution as for the specified product.
 - 3. Will coordinate installation and make changes to other work which may be required for the work to be complete with no additional cost to the Government.
 - 4. Waives claims for additional costs or time extension which may subsequently become apparent.
 - 5. Will reimburse the Government for review or redesign services associated with re-approval by authorities.
- E. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals, without separate written request, or when acceptance will require revision to the Contract Documents.
- F. Substitution submittal procedure is specified in Bidding and Contracting Requirements and Division 01.

1.7 MATERIALS AND EQUIPMENT

- A. All materials and equipment shall be new and the best of their respective kinds, suitable for the conditions and duties imposed on them by the project, and of representative manufacture. The description, characteristics and requirements of the materials to be used shall be in accordance with the specifications.
- B. All equipment, construction and installation must meet requirements of local, state and federal governing codes.

- C. Singular number: In cases where material, a device, or part of the equipment is referred to in the singular number in the specifications, it is intended that such reference shall apply to as many items of material, devices, or parts of the equipment as are required to complete the installation as shown on the drawings or required for proper operation of the system.
- D. Terms have the following meanings:
 - 1. Furnish: Supply item
 - 2. Install: Mount and connect item
 - 3. Provide: Furnish and install.
- E. All materials and equipment shall be installed and completed in a first class and workmanlike manner and in accordance with the best modern methods, practice and manufacturers' instructions. Any work which shall not present an orderly and neat or workmanlike appearance shall be removed and replaced with satisfactory work when so directed in writing by the DGS Project Manager.
- F. The specifications and drawings are intended to define the minimum requirements, as to quality of materials, construction, finish and overall workmanship.
- G. General Conditions describe the correlation and intent of the Contract Documents. In case of discrepancies between the specifications and drawings, the specifications should be followed as to the general methods and principles and the drawings followed as to sizes, capacities and specifics for corresponding parts. If sizes are omitted, the DGS Project Manager will determine sizes to be utilized.
- H. In all cases of doubt, uncertainty, or conflict as to the true meaning of the specifications or drawings, it is the responsibility of the Contractor to notify the DGS Project Manager of said uncertainty, doubt, or conflict and obtain a decision as to the intent before starting any work which may be affected by this decision.

1.8 COORDINATION

- A. Should a situation develop during construction to prevent the proper installation of any equipment or item where shown on the drawings, call the situation to the attention of the DGS Project Manager and await a written decision.
- B. Plan and coordinate all work to proceed in an orderly and continuous manner without undue delay, and in conformance with project schedule. Submit samples, shop drawings, schedules, insurance policies and certificates, and the like in time to avoid delays in actual construction. Coordinate HVAC work so that work of each trade is completed before other construction begins which would obstruct it.
- C. Coordinate trades to ensure that proper clearances between work of the various trades allow access to items which require operation and maintenance.
- D. Coordinate location and elevation of all piping, ductwork, light fixtures, equipment, and appurtenances in such a manner that the finished installation is as indicated on drawings. In the event difficulties are encountered which prevent this, it is the Contractor's responsibility to bring this to the attention of the DGS Project Manager prior to initiation of work. Correct improperly coordinated installation at no additional cost.

- E. The Contractors' assistants shall include a competent foreman, who shall be on the premises at all times to check, lay out, coordinate and superintend the installation of work. The foreman shall establish all grades and lines relative to the work before starting, and be responsible for the accuracy thereof.

1.9 SUBMITTALS

A. Manufacturers' and subcontractors' lists:

- 1. As specified in Division 01, submit a complete list of proposed manufacturers for all equipment, materials and subcontractors used for the work of this division. Lists shall follow the sequence of the specifications. No considerations will be given for partial or incomplete lists. After review of lists, submit shop drawings and product data.

B. Shop drawings and product data:

- 1. Submit in accordance with the requirements of Division 01 or as established at the preconstruction conference, the required number of copies of shop drawings and product data for every item of equipment. Shop drawings or product data will not be considered until manufacturers' lists have been approved. Shop drawings and product data shall be submitted, as required by the General Conditions, with sufficient time for checking, return to Contractor, and resubmission as required before Contractor shall install any item.
- 2. Each item submitted shall be properly labeled, indicating the specific service for which the equipment or material is to be used, section and paragraph number of specification or drawing number to which it applies, Contractor's name and project name and number. Data submitted shall be specific and shall include product data and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents. Clearly identify each item within the data. Data of a general nature will not be accepted. Each sheet must clearly show the project name and number.
- 3. The review of a shop drawing or product data shall not be considered as a guarantee of the measurements or building conditions or that the shop drawings or product data have been checked to see that item submitted properly fits the building conditions. This review shall not relieve the Contractor of the responsibility for furnishing material or performing work as required by the contract documents, for correctness of dimensions and quantities, or for proper coordination of details and interfaces among trades.
- 4. All exclusively electrical items furnished as items associated with mechanical items but not specifically described in the mechanical item submission, shall be submitted as a separate submittal but shall be clearly marked as associated with the mechanical item by identification specification paragraph.
- 5. Product data sheets shall be 8.5-inches by 11-inches cut sheets for operating and maintenance manual.

C. Submit at least three copies of the results of every test required under any section in this division.

D. Specialist shall submit a list of at least three projects similar to this project in type, size, and quality, which have been in place and operating satisfactorily for at least five years.

- 1. Include project name, address, name and phone number of Government's representative, and project type and size.

E. After the work is completed, submit all required certificates of approval from approved inspection agencies and authorities having jurisdiction over work of this division. Certificates of approval must be received by the Government prior to final acceptance of the work.

1.10 SPECIALIST

- A. The term "Specialist" as used in the specification shall mean an individual or firm of established reputation (or, if newly organized, whose personnel have previously established a reputation in the same field,) which is regularly engaged in, and which maintains a regular force of workers skilled in either (as applicable) manufacturing or fabricating items required by the contract, installing items required by the contract, or otherwise performing work required by the contract. Where the specification requires installation by a specialist, the term shall also be deemed to mean the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform the work under the manufacturer's direct supervision.

1.11 CONTRACT CLOSEOUT SUBMITTALS

A. Project record documents:

1. Maintain on site one set of the following record documents; record actual revisions to the work of this division:
 - a. Contract drawings.
 - b. Specifications.
 - c. Addenda.
 - d. Change orders and other modifications to the Contract.
 - e. Reviewed shop drawings, product data, and samples.
2. Maintain record documents separate from documents used for construction.
3. Record information concurrent with construction progress.
4. Specifications: Legibly mark and record in each section a description of actual products installed, including the following:
 - a. Manufacturer's name and product model and number.
 - b. Product options, substitutions, or alternates utilized.
 - c. Changes made by addenda and modifications.
5. Record documents and shop drawings: Legibly mark each item to record actual construction, including:
 - a. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the work.
 - b. Field changes of dimension and detail.
 - c. Details not on original Contract Drawings.
6. Submit documents as specified in Division 01.

B. Operation and maintenance data:

1. Submit sets prior to final inspection as specified in Division 01. Unless otherwise specified in Division 01, submit no fewer than three sets. In addition to requirements specified in Division 01, submit operating and maintenance manuals for the work of this division as specified below.
2. Lubrication charts: Prepare lubrication charts for each piece of mechanical equipment that requires grease or oil.
 - a. Include the following:
 - 1) Types of lubricants required.

- 2) Locations of lubrication points.
 - 3) Frequency of lubrication.
- b. Provide one extra set of lubrication charts mounted in plastic covers, besides those required in Operating and Maintenance Manuals.
3. Binders: Three-ring binders with vinyl-covered hard covers. Provide large enough binders, and sufficient quantity, that the required contents can be easily turned, removed, and reinserted.
 4. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS," and title of project. Print on spine of binder "O & M INSTRUCTIONS." If more than one binder is required, print covers and spines with volume numbers. Include in the front of every binder an index to all binders.
 5. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
 6. Contents: Prepare a Table of Contents for each volume, with each product or system description identified, typed on white paper.
 7. Part 1: Directory, listing names, addresses, and telephone numbers of mechanical engineers; Contractor; mechanical subcontractors; and major mechanical equipment suppliers.
 8. Part 2: Operation and maintenance instructions, arranged by specification section. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:
 - a. Significant design criteria, including pump and fan curves and similar performance charts.
 - b. List of equipment, including operating weight of each piece.
 - c. Parts list for each component, including recommended spare parts list.
 - d. Operating instructions.
 - e. Maintenance instructions for equipment and systems.
 - f. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.
 - g. Valve charts, including locations of flow fittings.
 9. Part 3: Project documents and certificates, including the following:
 - a. Shop drawings and product data.
 - b. Air balance reports.
 - c. Photocopies of certificates.
 - d. Photocopies of warranties and guarantees.
 - e. Test reports: Copies of the results of all tests required under all sections of specifications.
 10. Submit one copy of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection, with Engineer comments. Revise content of documents as required prior to final submittal.
 11. Submit final volumes revised, within ten days after final inspection.

1.12 REGULATORY REQUIREMENTS

- A. When these specifications call for materials or construction of a better quality or larger sizes than required by the following codes and standards, the provisions of the specifications shall take precedence.

- B. Provide, without extra charge, any additional materials and labor which may be required for compliance with these codes and standards even though the work is not mentioned in these specifications or shown on the contract drawings.
- C. Perform the work of this division in strict accordance with the following authorities. The latest revision of these codes accepted by the authority having jurisdiction as of the date of the contract documents shall apply.
 - 1. The plumbing, mechanical, electrical, building, fire, and safety codes of the state and county or city in which the work is being performed.
 - 2. The National Electric Code, NFPA 70 (NEC).
 - 3. The National Fire Protection Association Code. (NFPA).
 - 4. International Energy Conservation, Fire, Fuel Gas, Mechanical, and Plumbing Codes (ICC).

1.13 REFERENCE STANDARDS

- A. Perform the work of this division using the standards of the following organizations, as referred to in technical sections, as a minimum requirement for construction and testing. Unless specified otherwise in Bidding and Contract Documents or Division 01, the latest revision current as of the date of the contract documents shall apply. Products shall be certified by manufacturers to meet the requirements of referenced standards.
 - 1. Federal Specifications (FS)
 - 2. Military Specification (MS)
 - 3. Military Standards (Mil. Std.)
 - 4. Air Conditioning and Refrigeration Institute (ARI)
 - 5. Air Movement and Control Association (AMCA)
 - 6. Associated Air Balance Council (AABC)
 - 7. American Association State Highway and Transportation Officials (AASHTO)
 - 8. American National Standards Institute (ANSI)
 - 9. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - 10. ASME International (ASME)
 - 11. American Society for Testing and Materials (ASTM)
 - 12. American Society of Sanitary Engineering (ASSE)
 - 13. American Water Works Association (AWWA)
 - 14. International Code Council (ICC)
 - 15. Manufacturer's Standardization Society of the Valve and Fittings Industry Inc. (MSS)
 - 16. National Electrical Code, NFPA 70 (NEC)
 - 17. National Electrical Manufacturer's Association (NEMA)
 - 18. National Fire Protection Association (NFPA)
 - 19. National Fuel Gas Code, NFPA 54
 - 20. National Sanitary Foundation (NSF)
 - 21. National Standard Plumbing Code (NSPC)
 - 22. The Occupational Safety and Health Act (OSHA)
 - 23. Piping and Drainage Institute (PDI)
 - 24. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA)
 - 25. Underwriters Laboratory Inc. (UL)
 - 26. Maryland Occupational Safety and Health Act (MOSHA)

1.14 TEMPORARY STORAGE

- A. Maintain upon premises, where directed, a storage area, and be responsible for all contents within these areas. Provide all security measures necessary for this area.

- B. Area shall be maintained and shall be returned to original condition at the completion of the project.

1.15 PROTECTION

- A. Control dust resulting from construction work to prevent its spread beyond the immediate work area, and to avoid creation of a nuisance.
 - 1. Do not use water to control dust. Use drop cloths or other suitable barriers.
 - 2. In areas where dirt or dust is produced as a result of the work, sweep daily, or more often as required.
 - 3. Provide walk-off mats at entries and replace them at regular intervals.
 - 4. Construct dust partitions, where indicated on the drawings or as required.
 - 5. Protect areas occupied by Government personnel or equipment.
- B. Each trade and subcontractor is responsible for preventing damage and soiling of work performed by other trades or subcontractors. Each trade and subcontractor is responsible for providing temporary protection of its own work.
 - 1. Protect work from spills, splatters, drippings, adhesives, bitumens, mortars, paints, plasters, and damage from welding or burning.
 - 2. Protect finished work from damage, defacement, staining, or scratching.
 - 3. Protect finishes from cleaning agents, or grinding and finishing equipment.
 - 4. Protect adjacent and finished work from damage, using tape, masking, covers or coatings and protective enclosures.
 - 5. Coordinate installations and temporarily remove items to avoid damage from finishing work.
- C. Repair all damage or soiling to the complete satisfaction of the DGS Project Manager; replace any materials or work damaged to such an extent that they cannot be restored to their original condition, all at no addition to the Contract Sum.
- D. Protect work stored in place and supplies stored in the building.
 - 1. Store materials and products, subject to damage from moisture, in dry locations. If necessary, protect in wraps or covers.
 - 2. Store plastics, other materials, and products subject to damage from heat or cold at manufacturer's recommended temperatures.
- E. Use of sidewalk or roadway areas outside of the property lines shall be with permission and approval of the local authorities having jurisdiction.

1.16 FIRE PROTECTION

- A. As a minimum, provide hand-carried, portable, UL-rated extinguishers with each work crew working inside the building.
- B. Select extinguishers in accordance with NFPA 10 and NFPA 241 for classification, extinguishing agent, and size required by location and class of fire exposure.

1.17 PROJECT CONDITIONS

- A. Drawings showing utilities in concealed locations are based on the best information available but are not represented as being precisely correct. Work of the contract includes digging, cutting, drilling, using nondestructive methods, and other methods of locating concealed utilities in the field, as well as patching and repairing as specified in "Cutting and Patching" below.

- B. If, in the course of the work, workers encounter a material they suspect to present some hazard:
 - 1. Promptly notify the DGS Project Manager in writing.
 - 2. Do not perform any work which would disturb the suspected material until written instructions have been received.

1.18 WARRANTY

- A. All work and equipment provided as work of this division shall be fully warranted under the general project warranty. In addition, provide added special warranties specified in individual sections.
- B. During the correction period, the Contractor shall begin correcting any work found to be not in accordance with the requirements of the Contract Documents within 4-hours of receiving written notice from the DGS Project Manager. Provide detailed schedule for completion of work within 24-hours of receiving written notice from the DGS Project Manager and revise schedule based on any Government comments generated. Except as otherwise required in General Conditions and Division 01, the correction period is one year after the date of substantial completion of the work. Work requiring correction shall promptly be repaired or completely replaced at no addition to the Contract Sum.
 - 1. Service reports for warranty work shall be provided to the Government.
- C. When use of the permanent equipment has been permitted for temporary heating or ventilation of the building, the warranty and correction periods shall nevertheless begin at the time of substantial completion, unless another date of acceptance has been agreed to by the Government.
- D. Special warranties are warranties required by individual specification sections, incidental product warranties, manufacturers' standard warranties, installer or subcontractor service agreements, and other individual warranties in addition to the general project warranty.
- E. Provide copies of warranties as required for Operation and Maintenance Manual specified above, and by Division 01.
- F. For items of work delayed beyond date of substantial completion, provide updated submittal within ten days after acceptance, listing date of acceptance as start of warranty period.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 CUTTING AND PATCHING

- A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
- B. Cut walls, floors, partitions, roofs, and other appurtenances for the passage or accommodation of pipes, ducts and appurtenances. Close superfluous openings and remove all debris caused by work of this division.

- C. No cutting of any structure or finish shall be done until the condition requiring such cutting has been examined and approved by the DGS Project Manager.
- D. New or existing surfaces disturbed as a result of such cutting or otherwise damaged shall be restored to match original work and all materials used for any patching or mending shall conform to the class of materials originally installed.
- E. Refinish surfaces to match adjacent finish. For continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit.

3.2 TEMPORARY FACILITIES

- A. Temporary water facilities, electricity, telephone, toilet facilities, and temporary heat, shall be provided as specified in Division 01.

3.3 PROGRESS MEETINGS

- A. Progress meetings shall be held as specified in Division 01, and also when and if the Contractor or DGS Project Manager finds them necessary or advantageous to progress of work.
- B. Contractor, those subcontractors and those material suppliers concerned with current progress or with the scheduling of future progress, and the DGS Project Manager shall each be represented at these meetings by persons familiar with the details of work and authorized to conclude matters relating to work progress.

END OF SECTION

SECTION 23 0500

COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Requirements applicable to more than one section of Division 23.
- B. Basic material and equipment required for the HVAC piping work.
- C. Identification of HVAC systems and equipment.
- D. Cleaning and painting.
- E. Treated wood lumber.
- F. Operating instructions.
- G. Piping tests.

1.2 RELATED SECTIONS

- A. Project and special warranties: Division 01 and Section 23 0101.
- B. Operation and Maintenance Manuals: Division 01 and Section 23 0101.
- C. Painting: Division 09.

1.3 REFERENCES

- A. American Society of Mechanical Engineers
 - 1. ASME Boiler and Pressure Vessel Code
 - 2. ASME A 13.1: Scheme for the Identification of Piping Systems
 - 3. ASME B 31.1: Power Piping
 - 4. ASME B 31.9: Building Services Piping
- B. American Society of Testing and Materials
 - 1. ASTM A 234: Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
 - 2. ASTM B 32: Standard Specification for Solder Metal
 - 3. ASTM B 88: Standard Specification for Seamless Copper Water Tube
 - 4. ASTM B 813: Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
 - 5. ASTM D 635: Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
 - 6. ASTM E 84: Standard Test Method for Surface Burning Characteristics of Building Materials
 - 7. ASTM E 548: Standard Guide for General Criteria Used for Evaluating Laboratory Competence
- C. American Welding Society

1. AWS D1.1: Structural Welding - Steel
2. AWS D10.9: Specification for Qualification of Welding Procedures and Welders for Piping and Tubing
3. AWS QC1: Specification for AWS Certification of Welding Inspectors

1.4 DEFINITIONS

- A. Project correction period: A period after Substantial Completion of the work during which the Contractor shall correct every part of the work found to be not in accordance with the requirements of the contract documents, promptly after receipt of written notice.
- B. Qualified testing agency: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E 548; and with additional qualifications specified in individual sections; and where required by authorities having jurisdiction, that is acceptable to authorities.
 1. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.
 2. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program.
- C. DN: Dimension Nominale, nominal pipe size in millimeters, in accordance with the metric system for construction, Systeme Internationale (SI).
- D. NPS: Nominal pipe size in inches, in accordance with standard U.S. designations for manufactured pipe. Pipe sizes do not change when projects are designed and built in metric units; each size has a consistent name (nominal dimension) in each system.

1.5 DESIGN REQUIREMENTS

- A. The drawings and system performances have been designed based on the use of the particular manufacturer's products specified and scheduled on the drawings.
- B. Products of other manufacturers that are listed under the article "Available Manufacturers," or permitted as "equal," are permitted provided:
 1. Product shall meet the specifications.
 2. Contractor shall make, without addition to the contract sum, all adjustments for deviations so that the final installation is complete and functions as the design basis product is intended.
- C. Do not propose products with dimensions or other characteristics different from the design basis product that render their use impractical, or cause functional fit, access, or connection problems.

1.6 SUBMITTALS

- A. Shop drawings:
 1. Schedule of welding and brazing procedures proposed for each piping system in the project.
 2. Shop drawings of backboards for piping specialties.
- B. Certifications: Proof of operator and testing agency personnel qualifications as required for welding and brazing in the article "Quality Assurance" below.
- C. Test reports: Field test results for each piping system as specified in Part 3 below.

1.7 QUALITY ASSURANCE

- A. Provide materials and perform work in accordance with the plumbing, mechanical, electrical, building, fire, health and safety, and other applicable codes and regulations of the state, county or city in which the work is performed.
- B. Welding procedures and operator qualifications for structural welding: AWS D1.1, Structural Welding Code Steel, electric arc process.
- C. Welding, brazing, and soldering procedures and operator qualifications for building systems piping:
 - 1. AWS D10.9, Qualification of Welding Procedures and Welders for Piping and Tubing.
 - 2. ASME B31.9, Building Services Piping.
 - 3. Copper Development Association "Copper Tube Handbook."
- D. Electrical control panels, equipment, materials and devices provided or installed as work of Division 23 shall bear UL label or, if UL label is not available, the item shall be tested and labeled by a qualified testing agency, acceptable to authorities having jurisdiction, and in accordance with NFPA 70 (NEC). Provide testing, if required, without addition to the contract sum.
- E. VOC content: Field-applied adhesives and sealants, limits per South Coast Air Quality Management District (SCAQMD), Rule No. 1168.
- F. Products shall contain no urea-formaldehyde content.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Piping techniques, testing, identification, painting, and operating instructions specified in this section apply to products specified in other sections of Division 23.
- B. Equipment that uses or processes date and time data in order to perform its function shall be warranted by the manufacturer to properly function and correctly use or process all time-related data for all dates and times which occur during a reasonable life expectancy of the equipment.

2.2 PIPING MATERIALS

- A. Weldolets and thredolets: Fittings designed for installing branches on piping, with either welded or threaded connection to branch; conforming to ASTM A 234.
- B. Soldering materials:
 - 1. Solder: Free of lead, antimony, and zinc and meeting the requirements of ASTM B 32. No solder containing lead is permitted.
 - a. Tin 95.5 percent, copper 4 percent, and silver 0.5 percent.
 - (1) Equal to "Silvabrite 100" manufactured by Engelhard Corporation.
 - b. Tin, copper, bismuth, and silver.
 - (1) Equal to "Oatey Silver" manufactured by Oatey.

2. Flux:
 - a. Meeting the requirements of ASTM B 813 and NSF 61 certified.
 - b. Equal to Oatey H-20⁹⁵.

2.3 IDENTIFICATION DEVICES AND MATERIALS

A. Stenciling materials:

1. Stencils: Manufactured standard stencils prepared for required applications, conforming to ASME A 13.1 for color and size of legend letters, including arrows showing direction of flow.
2. Paint: Exterior type enamel, colors conforming to ASME A 13.1, or black.

B. Equipment identification tags:

1. Laminated plastic with adhesive back, white core and black outer layers, which, when engraved, will produce white letters and numerals on a black background.
2. Tags installed on curved surfaces shall be aluminum or brass.

C. Valve tags: Brass, 1.5 inch (40 mm) in diameter with black-filled numbers not less than 0.25 inch (6 mm) high, complete with brass attachment chains.

D. Ceiling identification tags: Laminated plastic with adhesive back, engraved black letters on white background, minimum 0.5 inch (15 mm) wide and length as required for 0.375 inch (10 mm) high letters for name of concealed device and number.

2.4 TREATED WOOD LUMBER

A. Wood-preserved-treated lumber: Treated by pressure process, AWPA C2, with chemicals acceptable to authorities having jurisdiction, and marked with treatment quality mark of an inspection agency approved by ALSC Board of Review.

PART 3 - EXECUTION

3.1 GENERAL

A. Manufacturers' instructions: Except as modified by drawings or specifications, install products and equipment in accordance with manufacturers' instructions and recommendations applicable to the project conditions.

1. Immediately notify DGS Project Manager if a difference or discrepancy is found between manufacturers' instructions and the drawings or specifications.

B. The contract drawings are diagrammatic and do not indicate all fittings or offsets in pipe and ductwork, all access panels, or all specialties required. Provide required fittings, offsets, access panels, and specialties to coordinate the work.

C. No pipe or duct shall be run below the head of a window or door.

D. Equipment, ducts, and pipes installed in areas without a suspended ceiling shall be as tight to structure as possible, but at least above a height of 6'-8", unless otherwise noted.

E. Items which require access for operation or maintenance shall be easily accessible. Do not cut or form hand holes for operation or maintenance of appliances through walls or ceilings.

3.2 PIPE INSTALLATION

- A. Install pipe exposed to view parallel to building lines and as close to walls, columns, and ceilings as may be practical, maintaining proper clearances for access at all parts requiring servicing.
- B. Install pipe a sufficient distance from other work to permit a clearance of not less than 0.5 inch (15 mm) between its finished covering and adjacent work.
- C. Remove burrs resulting from cutting pipe or from any other operation.
- D. Thoroughly clean pipe and fittings before they are installed, and keep them clean until the acceptance of the completed work. Cap or plug the ends of the lines so as to prevent earth and other debris from entering during construction.
- E. Install unions or flanges in the piping at each item of equipment, control valve, and appliance, so as to provide easy removal of the equipment, valve, or appliance, and to provide for easy removal of coils.
- F. Interface with other products:
 - 1. Where pipe is provided through walls, provide finished, permanent, waterproof installation complete with inserts, sleeves, supports or hangers, seals, and other appurtenances as required. Do not pierce, cut, or notch any footing or other structural member.
 - 2. Waterproofing and dampproofing of the building shall be unharmed by the installation of the work. Where pipe has to pierce waterproofing or dampproofing, including outside walls, the penetration shall be made watertight. Waterproofing damaged or destroyed shall be repaired or replaced with new waterproofing.
- G. Thoroughly clean pipe and fittings before they are installed, and keep them clean until the acceptance of the completed work. Cap or plug the ends of the lines so as to prevent earth and other debris from entering during construction.
- H. Copper tubing installation:
 - 1. Cut pipe with a tubing cutter or fine-tooth saw. Cuts made with a saw shall be true and square, and the end shall be filed smooth with a fine-tooth file. Remove all marks and burrs with sandpaper.
 - 2. Solder joints for copper tubing: Clean ends of tubing and inside of fitting ends thoroughly with emery cloth before applying flux.
 - 3. Provide dielectric fittings between copper and steel piping to prevent electrolysis.
 - 4. Follow the techniques for soldering and brazing pipe, fittings, and valves as recommended by the manufacturer.

3.3 IDENTIFICATION

- A. General: Do not apply identification until insulation and finish painting work is complete.
- B. Equipment:
 - 1. Stencil equipment with minimum two-inch (50-mm) -high letters or provide identification tags. Clearly indicate equipment designation and area served.
 - 2. Firmly fasten each identification tag to its appropriate piece of equipment with drive screws, sheet metal screws, or rivets. Do not interfere with operation of, or damage the item being marked.

C. Piping:

1. Mark by stenciling.
2. Mark to identify service with arrows showing direction of flow. Apply markings near building walls where pipes enter or leave an accessible space and in intermediate locations so that markings are no more than 30 feet (9 m) apart. They shall be readily visible to a person standing on the floor.
3. Fully identify all piping installed as work of the project.
4. Mark pipe with letters of height and with colors as required by OSHA and conforming to ASME A 13.1.
5. Identify every thermometer, gauge, and control device.
6. Provide valve tags for all valves except shutoff valves on individual fixtures or equipment where their function is obvious, or where the fixture or equipment is immediately adjacent. Numbers shall correspond to those shown on the Valve Chart. Attach tags to valve shaft.

D. Ductwork: Stencil ductwork after insulation is applied, if required, with minimum two-inch (50-mm)-high letters, clearly identifying service (supply, return, exhaust) and showing direction of flow with arrows. Mark ducts near the building walls where they enter or leave a space, and at intervals of not more than 30 feet (9 m). Identification shall be visible to a person standing on the floor.

E. Ceiling identification tags: Provide on the access door or, in suspended ceilings, on the ceiling support adjacent to the unit.

1. Valves: Identify with the same number shown on the valve tag.
2. Terminal units above ceilings: Identify with unit description and number.

3.4 CLEANING AND PAINTING

A. Cleaning: Clean all piping and equipment. Where items are to be painted, clean ready for painting.

B. Painting: Coordinate painting with requirements of Division 09. Paint the items identified below to be painted. Use paint materials and systems specified in Division 09.

C. Items to be painted:

1. Items furnished with manufacturer's prime coat.
2. Mechanical rooms (including but not limited to boiler, chiller, and air-handling unit rooms):
 - a. Insulation and uninsulated steel: Piping, pumps, tanks, and vessels.
 - b. Hangers and supports.
3. Inside ducts behind registers, grilles, and diffusers.

D. Items not to be painted: Copper, stainless steel, and equipment furnished with manufacturer's finish.

E. Painting inside ducts behind registers, grilles, and diffusers: Matte black, compatible with substrate and suitable for the temperatures at which the duct will operate, extending from the duct opening to a depth such that no unpainted surface will be visible to a person standing on the floor or adjacent balconies.

3.5 TREATED WOOD LUMBER

- A. Provide wood-preservative-treated lumber where wood members are required as detailed on the drawings and in the following applications:
 - 1. Cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, or waterproofing.
 - 2. Sills, sleepers, blocking, and similar concealed members in contact with masonry or concrete.
 - 3. Framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.
 - 4. Framing members that are less than 18 inches (460 mm) above the ground in crawlspaces or unexcavated areas.

3.6 OPERATING INSTRUCTIONS (DEMONSTRATION)

- A. Furnish the necessary technicians, skilled workers, and helpers to operate all the HVAC systems and equipment of the entire project for one 8-hour day.
- B. Where specified in technical sections, provide longer periods required for specialized equipment.
- C. Instruct the Government's designated personnel in operation, maintenance, lubrication, and adjustment of all systems and equipment.
 - 1. Instructions by manufacturer's technical representative for each type of equipment shall include the performance of the recommended preventive maintenance procedures for that equipment.
- D. The Operating and Maintenance Manual shall be available at the time of the instructions, for use by instructors and Government personnel.
- E. Schedule the general and specialized instruction periods for a time agreed upon by the DGS Project Manager.

3.7 PIPING TESTS

- A. Refrigerant pipe testing: Test as specified in Section 23 2300.

END OF SECTION

SECTION 23 0502

SLEEVES AND PLATES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Sleeves and escutcheon plates for piping systems.
- B. Mechanical seals for piping penetrations.

1.2 SUBMITTALS

- A. Product data: Sleeves, plates, sealants, and mechanical penetration seals.

PART 2 - PRODUCTS

2.1 SLEEVES, PLATES, AND ACCESSORIES

- A. Steel sleeves: Schedule 40 black steel pipe, ASTM A 53.
- B. Sealing compound in walls and floors:
 - 1. Bare and insulated pipes carrying fluids 150 degrees F (65 degrees C) and below:
 - a. High-performance, moisture cured, 1-component, polyurethane-based, non-sag, elastomeric sealant. Use a primer for applications required by the manufacturer.
 - b. Basis of design: Sika Corporation "Sikaflex - Ia."
 - 2. Bare and insulated piping carrying fluids 151 degrees F (66 degrees C) and above:
 - a. One-part RTV silicone, neutral-cured, architectural grade sealant. Use a primer for applications required by the manufacturer.
 - b. Basis of design: Dow Corning Corporation "790 Silicone."
- C. Floor, wall, and ceiling plates for new piping: Stamped or cast brass with chrome finish and set screw.
- D. Mechanical penetration seals:
 - 1. Seals shall be modular mechanical type, consisting of interlocking synthetic links shaped to continuously fill the annular space between the pipe and wall opening. Bolt and nut fasteners for the seals shall be stainless steel for units used in penetrations below grade.
 - 2. Basis of design: PSI "Link-Seal Modular Seals" or Calpico Sealing Link "LINX".

PART 3 - EXECUTION

3.1 INSTALLING SLEEVES

- A. Install sleeves for piping, or piping with insulation continuous through sleeve, passing through walls, partitions, beams, or slabs.
- B. Do not cut, drill, or burn structural steel for installation of piping without specific instructions from the DGS Project Manager.

C. Locations in nonfire-rated construction:

1. Install steel sleeves for penetrations of insulated piping.

D. Install sleeves through walls and partitions flush with finished surfaces.

E. Sleeves for insulated piping with vapor barrier shall be large enough to pass piping and insulation.

F. Seal spaces between sleeves and pipe, or pipe insulation, in nonrated walls, with mineral wool.

G. Penetrations in exterior masonry or concrete walls and foundations:

1. Sleeves: Cast iron, or in cast concrete may be core drilled.

2. Above grade: Mechanical penetration seal, at outside face of wall.

3.2 INSTALLING PLATES

A. Exposed piping passing through interior walls, partitions, floors, and ceilings shall be fitted with plates of size and depth to conceal sleeves. Secure plates firmly in place with set screws.

END OF SECTION

SECTION 23 0504

HVAC DEMOLITION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Extent and location of demolition are shown on the drawings.

1.2 RELATED SECTIONS

- A. Demolition: Division 02.

1.3 REFERENCES

- A. ANSI/ASHRAE Standard 147: Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems.

1.4 QUALITY ASSURANCE

- A. Demolition shall be carried out as expeditiously as possible in accordance with accepted practice and applicable building code provisions.

1.5 PROJECT CONDITIONS

- A. If, in the course of the work, workers encounter a material they suspect to be asbestos, to contain lead or PCBs, or to present some other hazard:
 - 1. Promptly notify the DGS Project Manager in writing.
 - 2. Do not perform any work which would disturb the suspected material until written instructions have been received.
- B. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.
- C. Locate, identify, and protect mechanical and electrical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, install temporary services for affected areas.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Before beginning to remove equipment which contains refrigerants, remove refrigerants.
 - 1. Following the recommendations of ANSI/ASHRAE Standard 147 and requirements of local authorities having jurisdiction, and using approved equipment, recover refrigerants.

2. Store each type of refrigerant in a separate container which meets requirements for refillability.
3. Handle and store following the recommendations of ANSI/ASHRAE Standard 147.

3.2 DEMOLITION

- A. Comply with demolition and disposal requirements of Division 02.
- B. Perform removal work neatly with the least possible disturbance to the building.
- C. Provide temporary barriers, danger signals, and appurtenances for protection of personnel and equipment during removal operations.
- D. Demolish, remove, demount, and disconnect inactive and obsolete piping, fittings and specialties, equipment, ductwork, controls, fixtures, and insulation.
 1. Piping and ducts embedded in floors, walls, and ceilings may be abandoned in place if they do not interfere with new installations. Cut back to at least one inch below finished surface.
 2. Remove materials above accessible ceilings.
 3. Drain and cap items to remain behind finished surfaces.
 4. Patch and repair surface materials as required in Division 01 and Section 23 0101 article, "Cutting and Patching."
- E. Remove anchors, bolts, and fasteners associated with piping and equipment to be removed.

3.3 DISPOSAL

- A. Dispose of equipment and materials removed, and rubbish and waste material, as work progresses. Do not allow demolition debris to accumulate on site. Remove products of demolition from the building daily.

3.4 PROTECTION

- A. Provide adequate and positive protection to existing building and equipment that is to remain, particularly to prevent entry of either dust or water. Ensure weathertightness at all times. Keep standby patching materials on hand to patch and maintain protection as required.

END OF SECTION

SECTION 23 0513

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Unless otherwise specified in a particular section or required for a particular application, motors shall conform to the following requirements, whether factory-installed or field-installed.

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Motor capacitors: Section 26 0521, Wiring Connections.

1.3 RELATED WORK SPECIFIED ELSEWHERE

- A. Ductless split-system units: Section 23 8127.
- B. Air-source heat pump units: Section 23 8143.
- C. HVAC fans: Section 23 3400.

1.4 REFERENCES

- A. NEMA MG 1: Motors and Generators.
- B. NEMA MG 10: Energy Management Guide for Selection and Use of Polyphase Motors.
- C. NEMA MG 11: Energy Management Guide for Selection and Use of Single-Phase Motors.
- D. UL 508: Industrial Control Equipment.

1.5 DEFINITIONS

- A. Energy efficient motor: Motor meeting the nominal and minimum efficiency levels listed for its horsepower and speed in Table 12-10 of NEMA MG 1.
- B. Nominal efficiency: Efficiency as defined in Table 12-8, Efficiency Levels, in NEMA MG 1, and identified on the motor nameplate.

1.6 SUBMITTALS

- A. Product data:
 - 1. Motors and drives not provided with equipment: Show nameplate data and ratings; characteristics; mounting arrangements; size and location of winding termination lugs, conduit entry, and grounding lugs, and coatings.
 - 2. Motor capacitors.
- B. Wiring diagrams required for the proper installation of mechanical equipment.
- C. Submit product data which verifies compliance with ASHRAE 90.1 or provide certified performance ratings by a qualified independent testing agency.

D. Certifications:

1. Actual motor power factor for each motor, certified test results for each motor proposed for use on this project.
2. Field test showing corrected power factor, if required.

1.7 QUALITY ASSURANCE

- A. Actual motor power factor shall be tested and certified by an independent testing laboratory.
- B. UL label and local testing (if required): As specified in Section 23 0500, Common Work Results for HVAC.
- C. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.

1.8 REGULATORY REQUIREMENTS

- A. Motors shall conform to the requirements of NEMA MG1 and applicable portions of the National Electric Code (NEC, NFPA 70).

PART 2 - PRODUCTS

2.1 AVAILABLE MANUFACTURERS

A. Motors:

1. Baldor Electric Co.
2. Marathon
3. Rockwell
4. Siemens
5. A.O. Smith
6. Toshiba International
7. Or approved equal.

B. Motor capacitors:

1. ABB Power Distribution
2. Commonwealth Sprague
3. General Electric
4. Or approved equal.

2.2 BASIC MOTOR REQUIREMENTS

- A. Capacity: Each motor shall have sufficient capacity and torque to start, accelerate, and operate the machine it drives without exceeding the motor nameplate rating at the speed specified, or at any speed and load which may be obtained by the drive actually furnished.
- B. Starting: Each automatically controlled motor shall be capable of starting as frequently as the control sequence may demand. Motors not automatically controlled shall be capable of making no fewer than 4 starts per hour.
- C. Loads: Belt-connected motors shall be equipped with shafts and bearings designed to withstand both the normal connected loads of the drive furnished, and momentary loads imposed during acceleration.

- D. Ratings: Motors shall be rated for continuous duty at 100 percent of rated capacity, and temperature rise shall be based on ambient temperature of 40 degrees C.
- E. Phase: Unless otherwise indicated, motors one-half horsepower and larger shall be polyphase and motors smaller than one-half horsepower shall be single-phase motors.
- F. Motor construction:
 - 1. Motors for fans, and air handling units, unless specified otherwise in the equipment section, shall be open drip-proof NEMA design B construction.
 - 2. Motors where indicated or specified, motors mounted outdoors, shall be totally enclosed, fan-cooled (TEFC) extra severe-duty. Motors outdoors inside weather-tight enclosures may be open drip-proof type.
- G. Efficiency: The term "energy efficient" is defined in the article "Definitions" in Part 1 above.
 - 1. Single-phase motors, alternating-current fractional horsepower, rated 1/20 to 1 horsepower, 250 volts or less: NEMA MG 11, types and efficiencies selected for their applications.
 - 2. Polyphase motors, medium alternating-current, squirrel-cage, 1 to 500 horsepower, 600 volts or less: NEMA MG 10, energy-efficient types selected for their application. Nominal full-load efficiencies shall meet or exceed ratings of Table 12-10 of NEMA MG 1.
 - 3. Motors for packaged hermetic and semi-hermetic refrigeration compressors need not comply with these efficiency requirements but they shall comply with the requirements indicated for power factor and power consumption.

2.3 SINGLE-PHASE MOTORS

- A. Permanent split-capacitor or split-phase type.
- B. Bearings: Sealed, prelubricated ball-bearing type.

2.4 ELECTRONICALLY COMMUTATED MOTOR (ECM)

- A. Brushless direct current (DC) variable speed motor supplied with alternating current, with a permanent magnet with near zero rotor losses, permanently-lubricated ball bearings, electronic commutation, designed for synchronous rotation, and at least 70 percent efficient at all operating speeds.
- B. As a minimum, the motor shall include the following features:
 - 1. Integrated controller / inverter that operates the wound stator and senses rotor position to electronically commutate the stator.
 - 2. Thermal overload protection.
 - 3. Built-in soft start and soft speed change ramps.
 - 4. Inductors to minimize harmonic distortion and line noise.
 - 5. Designed to overcome reverse rotation without affecting life expectancy.
 - 6. Motor speed shall be controllable down to 20 percent of full speed. Speed shall be controlled by either a potentiometer with manual adjustment on the motor or by a 0-10Vdc analog signal from a remote source, as required by other sections of Division 23 specifications.
 - 7. Software for motor control shall be as indicated or described in other Division 23 specifications.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Mount direct-connected motors securely and in accurate alignment. The drive shall be free from both angular and parallel misalignment when both motor and driven machine are operating at normal temperatures.
- B. Provide each belt-connected motor with a securely mounted adjustable base to permit installation and adjustment of belts.
- C. Mount capacitors shipped separately beside motor connection box as required. Connect in accordance with the requirements of Division 26, Electrical.
 - 1. Test units at full rated load after the installation of the motor capacitors, and submit reports.

3.2 OPERATING INSTRUCTIONS

- A. As specified in Section 23 0500, provide operating instructions.

END OF SECTION

SECTION 23 0529

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Pipe hangers and supports.
- B. Trapeze pipe hangers.
- C. Metal framing systems.
- D. Insulation protection.
- E. Fasteners.
- F. Equipment foundations and supports.

1.2 RELATED SECTIONS

- A. Vibration control supports: Section 23 0548.
- B. HVAC Piping Insulation: Section 23 0719
- C. Duct supports: Section 23 3113.

1.3 REFERENCES

- A. American Society of Mechanical Engineers
 - 1. ASME B31.1: Power Piping.
 - 2. ASME B31.9: Building Services Piping.
- B. ASTM International
 - 1. ASTM A 36: Standard Specification for Carbon Structural Steel
 - 2. ASTM A 53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - 3. ASTM A 307: Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
 - 4. ASTM A 563: Standard Specification for Carbon and Alloy Steel Nuts ASTM A 1064: Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
 - 5. ASTM C 533: Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
 - 6. ASTM C 552: Standard Specification for Cellular Glass Thermal Insulation
 - 7. ASTM F 594: Standard Specification for Stainless Steel Nuts
 - 8. ASTM F 3125: Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated
- C. American Welding Society
 - 1. AWS-D.1.1: Structural Welding – Steel

D. Metal Framing Manufacturer's Association

1. MFMA-4: Metal Framing Standards Publication
2. MFMA-103: Guidelines for the Use of Metal Framing

E. Manufacturer's Standardization Society

1. MSS SP-58: Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

1.4 DEFINITIONS

- A. High Temperature Hot Systems: Operating temperatures 200 degrees F (93 degrees C) and above.
- B. Hot Systems: Operating temperatures 120 degrees F (49 degrees C) to 200 degrees F (93 degrees C).
- C. Ambient Systems: Operating temperatures 60 to 119 degrees F (16 to 48 degrees C).
- D. Cold Systems: Minimum operating temperatures 59 degrees F (15 degrees C) and below.

1.5 SUBMITTALS

A. Product data:

1. Provide manufacturer's literature showing compliance with specifications for each type of hanger, framing system, support, fastener and accessory materials.
2. Provide a schedule of piping types and sizes and associated pipe hanger types.
3. Provide a schedule of building attachment types and associated attachment hardware.
4. Provide a schedule of pipe types and sizes and proposed hanger spacing and support rod diameters.
5. Provide manufacturer's recommended pipe hanger spacing criteria for plastic piping.

B. Welding certificates.

1.6 QUALITY ASSURANCE

- A. Qualifications of welders: As specified in Section 23 0500, Common Work Results for HVAC.

PART 2 - PRODUCTS

2.1 AVAILABLE MANUFACTURERS

A. Pipe hangers:

1. Anvil International
2. Carpenter and Paterson, Inc.
3. Cooper Industries
4. National Pipe Hanger Corporation
5. PHD Manufacturing, Inc.
6. PHP Systems/Design
7. Or approved equal.

B. Metal framing systems:

1. Anvil International
2. Cooper Industries
3. Hydra-Zorb
4. PHD Manufacturing, Inc.
5. PHP Systems/Design
6. Unistrut
7. Or approved equal.

C. Pipe covering protection shields:

1. Anvil International
2. Carpenter and Patterson, Inc.
3. Cooper Industries
4. National Pipe Hanger Corporation
5. PHD Manufacturing, Inc.
6. Pipe Shields, Inc.
7. Rilco Manufacturing Co., Inc.
8. Or approved equal.

2.2 PIPE HANGERS AND SUPPORTS

A. General: Comply with requirements of MSS SP-58.

B. Hangers and clamps:

1. Typical interior applications: Galvanized steel or factory painted.
2. Exterior and corrosive applications: Stainless steel.

C. Supplemental materials:

1. Threaded rod: Continuously threaded.
 - a. Zinc-plated or galvanized carbon steel for indoor applications.
 - b. Stainless steel for outdoor and corrosive applications.
2. Nuts and washers: Provide the same material used for threaded rods (ASTM A 563 for steel, ASTM F 594 for stainless steel).
3. Structural carbon-steel shapes: ASTM A 36.
4. Steel pipe: ASTM A 53, Grade B, Type E (electric resistance welded), Schedule 40, black and galvanized steel.

D. Metal framing systems:

1. Description: Shop- or field-fabricated, pipe-support assembly made of channels, nuts, bolts, structural connections, accessories, fittings, and other manufactured components.
2. Standard: Comply with MFMA-4 for factory-fabricated components for field assembly.
3. Channels: Continuous slotted galvanized steel channel with inturred lips, width selected for applicable load criteria.
4. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
5. Metal framing system pipe clamps:
 - a. Galvanized steel clamp pipe support with elastic stop nut, and hex head machine screw, and manufactured to connect to metal framing system channels.

- b. For insulated piping: Clamp shall have friction tape on inside of clamp surface, manufactured to connect to pipe clamp insulating insert over pipe.
- c. For uninsulated piping: Clamp shall have an integral molded thermoplastic elastomer clamping insert on inside of clamp surface, manufactured to connect to uninsulated pipe.

E. Insulation protection:

1. Pipe covering protection shield:

- a. Shield: Galvanized steel, meeting the requirements of MSS SP-58 Type 40. Provide with alignment ridges when used in conjunction with pipe hanger.
- b. Structural insulation insert: Structural insulation insert to form the insulation for the lower half of, or the entire pipe circumference. Provide ASTM C 533, Type I calcium silicate with 100-psig (688-kPa) minimum compressive strength; or ASTM C 552, Type II cellular glass with 100-psig (688-kPa) minimum compressive strength. Insert thickness shall match adjacent piping insulation thickness.

2. Combination insulating insert and insulation protection shield:

- a. Insulating insert material for cold and ambient system piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) minimum compressive strength and vapor barrier. Insert thickness shall match adjacent piping insulation thickness.
- b. Insulating insert material for hot system piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa) minimum compressive strength; or ASTM C 552, Type II cellular glass with 100-psig (688-kPa) minimum compressive strength. Insert thickness shall match adjacent piping insulation thickness.
- c. Insulation protection shield: Galvanized steel.
- d. Insulating insert and insulation protection shield shall cover entire circumference of pipe.
- e. Insulating insert length: Extend 2 inches minimum (50 mm) beyond insulation protection shield.

3. Pipe covering protection saddle:

- a. Saddle: Steel, meeting requirements of MSS SP-58 Type 39
- b. Insulation insert: Insulating material located in the space between saddle and pipe.

4. Pipe clamp insulating insert:

- a. Insulating insert material: Closed-cell, sponge or expanded rubber, ASTM C 534, Type I for tubing material, with integral supports constructed from non-compressive closed cell material, single piece construction with self-adhesive closure strips. Insert thickness shall match adjacent piping insulation thickness. If insulation thickness is not available, provide maximum available thickness and seal insulation vapor barrier at thickness transition.
- b. Insulation protection jacket: Aluminum or stainless steel, bonded to insulation insert.
- c. Insulating insert and jacket shall cover entire circumference of pipe.
- d. Equal to Armacell "Armafix" insulating inserts.

2.3 FASTENERS

A. Mechanical expansion anchors:

1. Self-drilling type expansion shields or machine bolt drop-in anchors for drilled holes. Fasteners to floor slabs shall be vibration and shock resistant. Load applied to fasteners shall not exceed 25 percent of manufacturer's stated load capacity in 3500 psi (24,000 kPa) concrete. Provide zinc-coated anchors for indoor applications and stainless-steel anchors for outdoor applications.
2. Basis of design: ITT Phillips Anchors "Red Head."

B. Fasteners to drywall or cavity wall construction:

1. Toggle bolts with hollow wall drive anchors or nylon anchors as required.
2. Basis of design: ITT Phillips Anchors "Red Head" toggle bolts.

C. Fasteners to wood construction: Lag bolts.

D. Bolts, nuts, and washers: ASTM A 307, or ASTM F 3125 where high strength is required.

2.4 CONCRETE AND GROUT

A. Concrete:

1. Concrete shall be no less than 3000-psi (25,000 kPa) strength.
2. Reinforcement: 6 by 6 inch (150 by 150 mm) welded steel wire fabric, ASTM A 1064.

B. Grout:

1. Premixed, non-shrink grout consisting of non-metallic aggregate, cement, and water-reducing and plasticizing agents; capable of developing minimum compressive strength of 7,000 psi (48,000 kPa) in 28 days.
2. Provide grout by one of the following manufacturers:
 - a. Sonneborn-Rexnord "SonogROUT"
 - b. L&M Construction Chemical Company "Crystex"
 - c. US Grout Corporation "Five-Star Grout"

PART 3 - EXECUTION

3.1 GENERAL

- A. Provide hangers and supports in accordance with schedules at the end of this section, as modified by specifications for each location and type.
- B. Comply with MSS SP-58. Provide hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- C. Provide hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- D. Where required, provide structural steel shapes or metal framing system channels and hardware to transfer load from a hanger location to multiple locations in the structure in order to get support from an appropriate location or to increase the strength of the connection to the structure.
- E. Support horizontal piping from above with hangers and threaded rod where possible, unless otherwise indicated.
- F. Support pipe risers through floor slabs with riser clamps.

- G. Provide hanger sizes to allow for continuous insulation for insulated piping systems.
- H. Fabricate wall-mounted and floor-mounted supports using metal framing systems or structural steel where required.
- I. Support groups of small piping along a structural wall using a metal framing system secured to the wall.
- J. Trim threaded rods with a maximum excess length of 1 inch (25 mm). Provide protective rubber red end caps on the ends of threaded rods exposed and within 8 feet (2.4 meters) of the floor, roof, or grade below.
- K. 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.
- L. Install lateral bracing with pipe hangers and supports to prevent swaying.
- M. Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- N. Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- O. Coordinate with requirements for hangers that require vibration control. See Section 23 0548.
- P. Metal framing systems: Provide where required for grouping of parallel runs of piping, and support together on field-assembled strut systems. Comply with MFMA-103 for metal framing system selections and applications.

3.2 BUILDING ATTACHMENTS

- A. Attaching to structural walls:
 - 1. Provide a minimum of two 0.375 inch (9.5 mm) minimum screw-type fasteners for attaching brackets and a minimum of three 0.5 inch (13 mm) minimum bolt-type fasteners for attaching structural supports.
- B. Attaching to concrete slabs and composite slabs:
 - 1. Obtain approval from the structural engineer and confirm allowable loads prior to supporting pipe from concrete slabs or composite slabs. Where approved, provide mechanical expansion anchors and steel bolts or rods.
- C. Attaching to wood construction:
 - 1. Trusses: Follow roof truss manufacturers' recommendations for attachment locations, loads, spacing, and methods of attachment.
 - 2. Joists: Provide MSS SP-58 Type 34 side beam connectors.

3.3 INSTALLING EQUIPMENT FOUNDATIONS AND SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor. Provide lateral bracing, to prevent swaying.

- B. Provide minimum four-inch (100-mm) -high concrete foundations (housekeeping pads) or as indicated on drawings, reinforced with welded-wire fabric, for floor-mounted equipment and where indicated. Anchor concrete foundations by dowels inserted into the floor slab.
- C. Unless otherwise specified, provide concrete foundations, bolts, sleeves, and appurtenances as work of the section where the supported equipment is specified and in accordance with the requirements of Division 03.
- D. Equipment shall be properly aligned and leveled, and grouted where necessary. Support piping independently of equipment and so as not to cause a strain or thrust.
- E. Coordinate exact size, configuration and location of equipment, foundations, and supports using approved shop drawings of equipment.

3.4 PIPING HANGER AND SUPPORT SCHEDULES

- A. Refrigerant piping applications:

HANGERS & SUPPORTS FOR REFRIGERANT PIPING APPLICATIONS		
MSS SP-58 Classification	Description	Piping applications
Hung from Above		
N/A	Metal framing system with metal framing system pipe clamps and pipe clamp insulating inserts.	All sizes.
Supported from Below		
N/A	Metal framing system with metal framing system pipe clamps and pipe clamp insulating inserts.	All sizes.
Risers		
Type 8	Riser clamp.	All sizes

- B. Minimum threaded rod sizes: Provide at least the following minimum rod diameters for single rods supporting a single pipe hanger.

PIPE SIZE	MINIMUM ROD DIAMETER
NPS 2 (DN 50) and below	0.375 inches (10 mm)

END OF SECTION

SECTION 23 0548

VIBRATION CONTROL SUPPORTS FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Vibration control supports for HVAC equipment.

1.2 RELATED SECTIONS

- A. Hangers and supports: Section 23 0529.
- B. Flexible duct connections: Section 23 3300.

1.3 SUBMITTALS

- A. Product data: For each type of vibration control support included in the work.
 - 1. For Specification D hanger, include scaled drawing showing degrees of hanger rod swing.
- B. Shop drawings: Custom-fabricated supports.

PART 2 - PRODUCTS

2.1 AVAILABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified Mason Industries product, or comparable product by one of the following:
 - 1. Amber/Booth Company, Inc.
 - 2. Kinetics Noise Control
 - 3. Mason Industries
 - 4. Vibro-Acoustics
 - 5. Vibration Eliminator Company, Inc.
 - 6. Vibration Mountings and Controls, Inc.
 - 7. Or approved equal.

2.2 VIBRATION CONTROL SUPPORTS

- A. Provide engineered supports for equipment and locations shown on drawings and specified in Part 3 below. The units shall prevent the transmission of vibration and mechanically transmitted sound to the building structure.
 - 1. Select units in accordance with the weight distribution of the equipment, so as to produce reasonably uniform deflection. Deflections shall be as specified.
 - 2. Units installed on exterior shall be galvanized.
- B. Specification A:
 - 1. Double-deflection neoprene type. All metal surfaces shall be covered with neoprene and have friction pads both top and bottom. Provide bolt holes for mounting. Provide steel rails where necessary to compensate for equipment overhang.
 - 2. Basis of design: Mason Industries ND.

- C. Specification B: Free-standing spring isolators, laterally stable without housing, and with 0.5-inch (13-mm) thick neoprene pads between baseplate and support.
1. Mountings shall have leveling bolts rigidly bolted to equipment.
 2. Springs: Spring diameters shall not be less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal of 50 percent of the rated deflection.
 3. Basis of design: Mason Industries SLFH.
- D. Specification D: Hangers, combination spring and minimum 0.3-inch (8-mm) deflection neoprene in series.
1. Neoprene element: Molded with a rod isolation bushing that passes through the hanger box.
 2. Spring diameters and hanger box lower hole sizes: Large enough to permit the hanger rod to swing through a 30-degree arc before contacting the edges of the hole.
 3. Springs shall have a minimum additional travel to solid equal to 50 percent of rated deflection.
 4. Basis of design: Mason Industries Type 30N.
- E. Specification E: Hangers, combination spring and minimum 0.3-inch (8-mm) deflection neoprene in series with adjustment to transfer load to spring while holding supported object at fixed elevation. Include spring deflection indicator.
1. Neoprene element: Molded with a rod isolation bushing that passes through the hanger box.
 2. Spring diameters and hanger box lower hole sizes: Large enough to permit the hanger rod to swing through a 30-degree arc before contacting the edges of the hole.
 3. Springs shall have a minimum additional travel to solid equal to 50 percent of rated deflection.
 4. Basis of design: Mason Industries Type PC30N.
- F. Specification X: Horizontal thrust restraint, consisting of a spring element in series with a neoprene pad as described in Specification B with the same deflection specified for the mountings or hangers.
1. Spring element: Contained within a steel frame and designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 0.25 inch (6 mm) movement at start and stop.
 2. Furnish the assembly with one rod and angle brackets for attachment to both the equipment and ductwork or the equipment and the structure.
 3. Horizontal restraints: Attached at the centerline of thrust and symmetrically on either side of the unit.
 4. Basis of design: Mason Industries WB.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Adjust vibration control supports as recommended by manufacturer to eliminate transmission of vibration to building structure or other systems.
- B. Replace springs that become permanently deformed with new springs.
- C. Provide 0.25-inch (6-mm) structural plate sized as required between isolator and equipment.

3.2 FAN VIBRATION CONTROL

- A. Suspended from structure: Provide Specification D hanger, selected for weight, with minimum 1.0 inch static deflection.

3.3 AIR-HANDLING UNIT VIBRATION CONTROL

- A. Isolators for air handling units may be provided as part of the unit (internal isolation) as specified in the section, Air Handling Units with Coils, but shall meet the requirements of this section.
- B. On floors above grade and on roofs: Provide number of Specification B mountings, having at least 1.75 inch (45 mm) static deflection, required to properly support unit and its accessories as recommended by the air-handling unit manufacturer.
 - 1. Unit with fan section isolated from coil and filter section:
 - a. Provide the Specification B mounting under fan and motor only, bolted to equipment support (housekeeping pad).
 - b. Provide Specification X mounts on each side between fan and coil section to control fan section thrust upon fan start-up.
- C. Suspended from structure: Provide Specification D hanger, selected for weight, with minimum 1.0 inch static deflection.

3.4 REFRIGERATION COMPRESSOR VIBRATION CONTROL

- A. Refrigeration compressors and equipment with self-contained refrigeration compressors:
 - 1. Refrigeration compressors, condensing units, and other rotating equipment mounted on floor slab on earth: Specification A mountings having at least 0.35 inch (89 mm) static deflection.

3.5 VIBRATION CONTROLS ON PIPING

- A. Piping: Provide Specification E vibration control supports in first three hangers at both the suction and discharge of compressors, and condensing units, and for the first three hangers on pipes connected to air handling units. The static deflection shall be the same as specified for the mountings under the connected equipment.
 - 1. If piping is connected to equipment mounted on slab on grade and hangs from structure under occupied spaces, the first three hangers shall have at least 0.75 inch (19 mm) deflection for pipe sizes up to and including NPS 3 (DN 80), 1.5 inch (38 mm) deflection for pipe sizes up to and including NPS 6 (DN 150) and 2.5 inch (64 mm) deflection thereafter.
 - 2. Other hangers and mounts shall have a minimum spring deflection of 0.75 inch (19 mm).
 - 3. Locate vibration control supports in hanger rods as close to the overhead supports as practical. On supports with double rods, use two vibration control supports.

END OF SECTION

SECTION 23 0593

TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. The Contractor shall engage and the DGS Project Manager shall approve an independent balancing and testing subcontractor.
- B. This section includes testing, adjusting, and balancing HVAC systems to produce design objectives, including the following:
 - 1. Balancing airflow within distribution systems, including submains, branches, and terminals, to indicated quantities according to specified tolerances.
 - 2. Adjusting total HVAC systems to provide indicated quantities.
 - 3. Measuring electrical performance of HVAC equipment.
 - 4. Setting quantitative performance of HVAC equipment.
 - 5. Verifying that automatic control devices are functioning properly.
 - 6. Reporting results of the activities and procedures specified in this section.

1.2 RELATED SECTIONS

- A. Testing and adjusting requirements unique to particular systems and equipment are included in the sections that specify those systems and equipment.
- B. Field quality-control testing to verify that workmanship quality for system and equipment installation is specified in system and equipment sections.

1.3 PERFORMANCE REQUIREMENTS

- A. Select and obtain approval of the testing and balancing subcontractor at the earliest possible time and before beginning ductwork installation.
- B. The testing and balancing subcontractor shall visit the job site periodically, beginning with the initial stages of construction of the mechanical systems, and shall ensure that the necessary devices are properly installed so that specified testing and balancing can be performed.

1.4 SUBMITTALS

- A. Submit qualifications of testing and balancing subcontractor, as required in article "Quality Assurance" below.
- B. Submit certified balance report. In addition to general requirements for submittals, submit three copies of final reports and certificates, bound into a booklet.

1.5 QUALITY ASSURANCE

- A. Testing and balancing subcontractor qualifications:
 - 1. Current certified member of the Associated Air Balance Council, or certified by National Environmental Balancing Bureau for air and hydronic systems testing and balancing.
 - 2. Has successfully completed at least five projects of similar size and scope.

3. Not affiliated with any other subcontractor participating in this project. Work performed by the subcontractor shall be limited to testing, adjusting, and balancing HVAC systems.
- B. Testing and balancing work shall comply with one of the following standards:
 1. National Standards for Testing and Balancing Heating, Ventilating and Air Conditioning Systems, published by the Associated Air Balance Council.
 2. Procedural Standards for Testing Adjusting Balancing of Environmental Systems, published by the National Environmental Balancing Bureau.

PART 2 - PRODUCTS

2.1 EQUIPMENT

- A. Instruments: Approved and properly calibrated.
- B. Pyrometer surface temperature measurements may be used for piping system water temperatures where thermometer wells are not provided in the piping.

PART 3 - EXECUTION

3.1 VERIFICATION OF CONDITIONS

- A. Before beginning balancing, ascertain that systems are ready. Verify that filters for regular service are in place, as required in Section 23 4100, Particulate Air Filtration.

3.2 PREPARATION

- A. Witness air duct leakage tests required in Section 23 3113, Metal Ducts, and advise and approve the methods and instruments used.
- B. Using bench-calibrated instruments, field-calibrate pressure gages and dial-type duct thermometers.

3.3 BALANCING OF SYSTEMS, GENERAL

- A. Tabulate settings of temperature control devices and ascertain that thermostats, controllers, and valves are set at specified or approved positions. Verify and certify that the sequence of operation for each system is as shown on drawings, specified, or approved.
- B. Provide all labor and devices necessary for the testing and balancing work.

3.4 AIR SYSTEMS BALANCING

- A. Balance all air distribution, supply, return, exhaust, and outdoor air systems and equipment.
- B. Test and adjust fans to deliver design airflow at lowest possible speed. Adjust air-handling equipment to deliver the required air volumes. Note that air quantities scheduled on drawings do not include allowances for duct leakage. Preliminary adjustments of fan speed should be slightly in excess of scheduled airflow delivery. Make adjustments by adjusting adjustable sheaves, changing sheaves and associated belts, changing wiring connections of motors, or adjusting speed controller.

- C. Test and adjust system to design airflow requirements to the greatest extent possible. Manual volume dampers in ducts shall be adjusted to obtain required airflow rates at grilles, registers, and diffusers. Dampers integral to airflow devices should be fully open or minimally closed for airflow fine adjustments.
- D. Make pitot tube traverse of main supply, return, and outdoor air ducts to obtain total airflow for fan or air-handling unit.
- E. Adjust rooms or zones to design airflow (supply, return, and exhaust).
- F. Adjust general HVAC systems to design airflow within the following tolerances:
 - 1. Total system supply, return, and exhaust: (design to plus 10 percent).
 - 2. Outdoor air: (minus 5 percent to plus 5 percent).
 - 3. Total supply, return, and exhaust for a room or space: (minus 5 percent to plus 5 percent).
 - 4. Grilles, registers, and diffusers:
 - a. One per room or space: (minus 5 percent to plus 5 percent).
 - b. Two or more per room or space: (minus 10 percent to plus 10 percent).
- G. Grilles, registers, and diffusers:
 - 1. Identify each grille, register, and diffuser as to location and area. List manufacturer, type, and size.
 - 2. Identify type of testing equipment used.
 - 3. Test and adjust each grille, register, and diffuser to design airflow. List (design-actual) cfm (cubic meters per minute) and (design-actual) velocity in fpm (meters per second) when applicable.
 - 4. Adjust diffusers, grilles, and registers to minimize drafts. Adjust blades in supply diffuser straightening grids to ensure uniform air distribution across diffuser.
 - 5. Adjust linear slot diffusers to provide throw direction as indicated on the drawings. Unless otherwise noted, discharge pattern shall be horizontal. Where two-way throw is indicated, divide the number of slots equally for each direction.
- H. Test and record the following data, as applicable, for air-handling equipment:
 - 1. Manufacturer and model number.
 - 2. Total airflow (design-actual).
 - 3. Return air airflow (design-actual).
 - 4. Outdoor air airflow (design-actual).
 - 5. Total and external static pressure (design-actual). Include static pressure at suction, discharge, and between unit coil and filter components.
 - 6. Entering air temperatures (db heating, db and wb cooling).
 - 7. Leaving air temperatures (db heating, db and wb cooling).
 - 8. Motor horsepower (rated-actual).
 - 9. Voltage and phase (rated-actual).
 - 10. Fan speed, rpm (rated-actual).
 - 11. Amperage (rated-actual).
- I. In cooperation with the control manufacturer's representative, set adjustments of automatically operated dampers to operate as specified.
- J. Submit a certified report listing the specification requirements and the operating conditions of these items as follows:

1. DX coil:
 - a. Suction pressure
 - b. Suction line temperature
 - c. Entering air - D.B.
 - d. Entering air - W.B.
 - e. Leaving air - D.B.
 - f. Leaving air - W.B.
 - g. Outdoor air temperature - D.B.
 - h. Outdoor air temperature - W.B.

3.5 MARKING OF SETTINGS

- A. Following final balance procedures, permanently mark the settings of valves, splitters, dampers, and other adjustment devices, so that adjustment can be restored if disturbed at any time. Set memory stops on balancing valves. Return and make required adjustments after submittal and approval of the Certified Balance Report.

END OF SECTION

SECTION 23 0700

HVAC INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Definitions and general requirements applicable to the insulation systems specified in "Related Sections."

1.2 RELATED SECTIONS

- A. HVAC piping insulation: Section 23 0719.
- B. Duct insulation: Section 23 0713.

1.3 REFERENCES

- A. ASTM E 84: Standard Test Method for Surface Burning Characteristics of Building Materials
- B. NFPA 255: Standard Method of Test of Surface Burning Characteristics of Building Materials
- C. UL 723: Standard for Test for Surface Burning Characteristics of Building Materials

1.4 DEFINITIONS

- A. Ceiling space: The space between the ceiling and the floor of an air-conditioned space above.
- B. Roof space: The space between the ceiling and the roof, where building insulation is located at the roof level or the space between the ceiling and the floor of a non-air conditioned space above.
- C. Attic space: The space between the ceiling and the roof, where building insulation is located at the ceiling level.
- D. Air-conditioned areas or spaces: Areas or spaces where the occupied room temperature is maintained between 65 and 80 degrees F (18.3 and 26.7 degrees C).
- E. Concealed insulation shall include work:
 - 1. Above ceilings.
 - 2. Where furred in and in pipe chases.
- F. Exposed insulation shall include work:
 - 1. In all rooms and areas.
 - 2. In mechanical equipment rooms, penthouses, or other similar utility spaces.
 - 3. In storage rooms.
- G. Unconditioned areas: Areas outside of the insulated envelope.
- H. Finished spaces: Areas of the building accessible to the public and to building occupants other than service personnel.

1.5 QUALITY ASSURANCE

- A. Perform work in strict accordance with the building, fire and safety codes of the state, county or city in which the work is performed.
- B. Insulation, including fittings and butt strips, jackets, facings, and accessories such as adhesives, mastics, cements, tapes and cloth, shall have a fire and smoke hazard rating and label as tested by ASTM E84, NFPA 255, and UL 723, not exceeding Flame Spread 25, Fuel Contributed 50, Smoke Developed 50.
- C. All insulation and accessories shall be free of asbestos.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver insulation and accessory products in manufacturers' wrapping or cartons, identified on the exterior and bearing labels showing conformance to flame and smoke rating requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Refer to sections listed in "Related Sections."

PART 3 - EXECUTION

Not Used.

END OF SECTION

SECTION 23 0713

DUCT INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Duct insulation as with the thickness and R-value indicated in the schedule at the end of this section.
- B. Work of this section includes:
 - 1. Insulation for new ductwork installed under this contract.
 - 2. Patching existing insulation where removed to make connections to existing ductwork.
 - 3. Patching existing insulation damaged during demolition and construction.

1.2 RELATED SECTIONS

- A. Painting: Division 09.
- B. Definitions and general insulation requirements: Section 23 0700.

1.3 REFERENCES

- A. American Society of Testing and Materials
 - 1. ASTM C 553: Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
 - 2. ASTM C 612: Standard Specification for Mineral Fiber Block and Board Thermal Insulation
 - 3. ASTM E 84: Standard Test Method for Surface Burning Characteristics of Building Materials

1.4 SUBMITTALS

- A. Material list: Each type of insulation and accessory, with manufacturer's name and material name and number. Identify locations for use, thickness of material, type of jacket, vapor barrier, and method of application.
- B. Product data: Sufficient to show that the product meets the specified requirements for materials, composition, and performance.
- C. Submit a single manufacturer for each product. Submittals that include multiple manufacturers for a single product are not acceptable.
- D. Installer qualifications.

1.5 QUALITY CONTROL SUBMITTALS

- A. Manufacturer's instructions: Recommended accessory materials and products; installation instructions.

1.6 QUALITY ASSURANCE

- A. Installer qualifications: Installers shall be mechanics skilled in this trade, employed with a firm that has a minimum of five years of experience installing mechanical insulation.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store rigid insulation products so as to protect them from breakage.

PART 2 - PRODUCTS

2.1 AVAILABLE MANUFACTURERS

- A. The listed manufacturers and particular products are intended to set a standard for materials, composition, and performance. Products of other manufacturers may be proposed as permitted by the provisions of Division 01 and the article "Product Options" in Section 23 0101.

- B. Mineral fiber insulation:

1. CertainTeed Corporation.
2. Johns Manville.
3. Knauf Fiber Glass GmbH.
4. Owens-Corning.
5. Or approved equal.

- C. Coatings, adhesives, and fabrics:

1. Childers
2. Foster
3. Manville Building Materials Group
4. Rock Wool Manufacturing Company
5. Trimac
6. Or approved equal.

2.2 MINERAL FIBER INSULATION MATERIALS

- A. Flexible mineral fiber insulation: ASTM C 553, Type I, nominal density at least 1 pound per cubic foot (16 kg per cubic meter), k-factor of 0.27 at 75 degrees F (k(SI) of 0.037 at 24 degrees C) mean temperature, of thickness as specified in Part 3 below, with foil-scrim-kraft vapor-barrier jacket. ASTM E 84 surface burning characteristics (flame spread/smoke developed) rating less than 25/50.

1. Minimum R-value of R-4.5 (RSI-0.79) with 1.5 inches (38 mm) of thickness in the installed condition with 25% compression.
2. Minimum R-value of R-6 (RSI-1.06) with 2 inches (50 mm) of thickness in the installed condition with 25% compression.

- B. Rigid mineral fiber insulation: ASTM C 612, Types IA-IB, nominal density at least 6 pounds per cubic foot (96 kg per cubic meter), with k-factor of 0.22 at 75 degrees F (k(SI) of 0.032 at 24 degrees C) mean temperature, of thickness as specified in Part 3 below, with factory-applied jacket composed of a reinforced white kraft and aluminum-foil laminate with the white kraft facing out. ASTM E 84 surface burning characteristics (flame spread/smoke developed) rating less than 25/50.

1. Minimum R-value of R-6.8 (RSI-0.79) with 1.5 inches (38 mm) of thickness.
2. Minimum R-value of R-9.1 (RSI-1.06) with 2 inches (50 mm) of thickness.

- C. Mineral fiber insulation accessories:

1. Mechanical fasteners: Adhesively attached, minimum 12-gauge zinc-plated steel pin welded to a 2 inch by 2 inch, 22 gauge minimum galvanized steel perforated baseplate and self-locking retaining washer. Pin length as required. Comply SMACNA HVAC Duct Construction for Mechanical Fasteners. Provide adhesive recommended by fastener manufacturer. Peel and press (self-sticking) type fasteners are not acceptable.
2. Tape for flexible mineral fiber insulation: Self-adhesive foil-scrim-kraft vapor-barrier tape with removable backing and pressure-sensitive acrylic adhesive, 3" (75 mm) wide minimum. ASTM E 84 surface burning characteristics (flame spread/smoke developed) rating less than 25/50.
3. Tape for rigid mineral fiber insulation: Self-adhesive foil faced vapor-barrier tape with removable backing and pressure-sensitive acrylic adhesive, 2" (50 mm) wide minimum. ASTM E 84 surface burning characteristics (flame spread/smoke developed) rating less than 25/50.
4. Mineral fiber insulation vapor barrier mastic:
 - a. Vapor barrier coating for use over ASJ jackets to give a vapor barrier seal at joints, laps and punctures. ASTM E 84 surface burning characteristics (flame spread/smoke developed) rating less than 25/50.
 - b. Basis of design: Foster 30-65 "Vapor-Fas".
5. Corner Angles: Aluminum, 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm).
6. Trapeze hanger support inserts: Calcium silicate insulation, ASTM C 533, Type I.

2.3 FIELD-APPLIED JACKETS

A. Canvas jacket:

1. Jacket material: 8 ounces per square yard (270 grams per square meter), fire-retardant treated.
2. Lagging adhesive:
 - a. Polyvinyl acetate water-based adhesive and coating used indoors to adhere and size canvas, glass cloth or other lagging fabric over pipe insulation, and able to be top coated with solvent-based paints. ASTM E 84 surface burning characteristics (flame spread/smoke developed) rating less than 25/50.
 - b. Basis of design: Foster 81-42W "Lagfas".
3. Lagging finish coating:
 - a. Washable, abrasion-resistant, indoor insulation coating for canvas. ASTM E 84 surface burning characteristics (flame spread/smoke developed) rating less than 25/50.
 - b. Basis of design: Foster 30-36 "Sealfas".

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

- A. Apply insulation in a neat and workmanlike manner and in accordance with manufacturer's printed instructions.
- B. Tape and seal terminations of insulation with vapor barrier mastic.
- C. Provide continuous insulation and jacket through trapeze hanger supports. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

- D. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- E. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- F. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- G. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- H. Install multiple layers of insulation with longitudinal and end seams staggered.
- I. Install insulation with least number of joints practical.
- J. Stagger joints.
- K. Install insulation continuously around hangers.
- L. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

3.2 INSTALLATION INSIDE BUILDINGS

- A. Install in accordance with the Minimum Insulation Thickness and R-Value Schedule at the end of this section.
- B. Concealed ducts: Provide flexible mineral fiber insulation.
 - 1. Mechanical fasteners: On ducts more than 24 inches (610 mm) wide, secure insulation on the underside with mechanical fasteners as required to prevent sagging, 16" (406 mm) maximum on center and 3" (75 mm) maximum from joints. Secure insulation in place with washers firmly embedded in insulation. Cut excess portion of pins extending beyond washers. Cover exposed pins and washers with tape.
 - 2. Transverse joints and longitudinal seams: Butt insulation with facing overlapping at least 2 inches (50 mm). Staple and seal with tape.
 - 3. Seal breaks and punctures with tape.
- C. Exposed ducts: Provide rigid mineral fiber insulation.
 - 1. Mechanical fasteners: Fastened with mechanical fasteners. Fasteners shall be spaced 16" (406 mm) on center with a minimum of two rows per side of duct and 3" (75 mm) maximum from joints. Secure insulation in place with washers firmly embedded in insulation. Cut excess portion of pins extending beyond washers. Cover exposed pins and washers with tape.
 - 2. Transverse joints and longitudinal seams: Provide a continuous unbroken vapor barrier. Create a facing lap by removing 2 inches (50 mm) from one edge and one end of insulation segments. Secure laps to adjacent insulation section with staples, 6 inches (150 mm) on center maximum. Seal seams and joints with tape.
 - 3. Seal breaks and punctures with tape.
 - 4. Apply corner angles to all outside corners and straight edges.
 - 5. For curved surfaces, such as exposed elbows, score or cut insulating board in narrow strips as necessary for snug and neat fit.
 - 6. Installing canvas jacket: Adhere canvas jacket with lagging adhesive. Finish with lagging finish coating, ready for painting.

- D. Ductwork which transmits air that may be either cooled or heated, or untempered air, shall be insulated as specified below for cooling systems.
- E. Where necessary to conceal the standing seams and reinforcing angles on exposed ducts, increase insulation thickness to 2 inches (50 mm).
- F. Casings and headers of reheat coils shall be insulated with the same thickness as adjacent ductwork.
- G. Installation on dedicated outdoor air ductwork.
 - 1. Conditioned outdoor air or supply air ducts from dedicated outdoor air systems shall be insulated as specified for supply air ducts for cooling systems.
 - 2. Return or exhaust air ducts from dedicated outdoor air systems shall be insulated as specified for return air ducts for cooling systems.

3.3 SCHEDULES

(See schedule, next page)

Minimum Insulation Thickness and R-Value for Duct Insulation Inside Buildings			
	Default Unless Otherwise Noted ¹	Ceiling, Chase, or Shaft Space in Air Conditioned Area	Attic Space and other Unconditioned Space
Outside Air and Exhaust Air			
Outdoor air	1.5 inch (38 mm)	Default	Default
Exhaust air from air- conditioned areas	Not required	Default	1.5 inch (38 mm) R-4.5 (RSI 0.79)
Exhaust air and pressure relief between exterior connection and ATC damper, but not less than 10 feet (3 meters)	1.5 inch (38 mm)	Default	Default
Cooling Systems			
Supply air	1.5 inch (38 mm)	Default	2 inch (50 mm) R-6 (RSI 1.06)
Pre-insulated round or oval supply air	1.5 inch (38 mm)	Not required	2 inch (50 mm) R-6 (RSI 1.06)
Return air and transfer	1.5 inch (38 mm)	Not required	2 inch (50 mm) R-6 (RSI 1.06)
Pre-insulated round or oval return air and transfer	Not required	Default	1.5 inch (38 mm) R-4.5 (RSI 0.79) ²
Heating Systems			
Supply air	1.5 inch (38 mm)	Default	2 inches (50 mm) R-6 (RSI 1.06)
Pre-insulated round or oval supply air	Not required	Default	2 inches (50 mm) R-6 (RSI 1.06)
Return air and transfer	Not required	Default	2 inches (50 mm) R-6 (RSI 1.06)
Pre-insulated round or oval return air and transfer	Not required	Default	2 inches (50 mm) R-6 (RSI 1.06)
Notes:			
1: Default insulation thickness shall be increased to 2 inches (50 mm) where necessary to conceal standing seams and reinforcing angles on exposed ducts.			
2: Insulation R-value added to the R-value of lined or pre-insulated duct exceeds R-6 (RSI 1.06)			

END OF SECTION

SECTION 23 0719

HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. HVAC piping insulation for the interior piping systems listed in the minimum insulation thickness schedule at the end of this section.
- B. HVAC piping insulation for the exterior piping systems.
- C. Work of this section includes:
 - 1. Insulation for new piping installed under this contract.
 - 2. Patching existing insulation where removed to make connections to existing piping.
 - 3. Patching existing insulation damaged during demolition and construction.

1.2 RELATED SECTIONS

- A. Firestopping: Division 07.
- B. Painting: Division 09.
- C. Definitions and general insulation requirements: Section 23 0700.
- D. Pipe hangers and protection shields: Section 23 0529.
- E. Pre-insulated refrigerant tubing system: Section 23 2300.

1.3 REFERENCES

- A. American Society of Testing and Materials
 - 1. Standards for flexible elastomeric insulation materials
 - a. ASTM C411: Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation
 - b. ASTM C 534: Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
 - 2. Standards for all insulation materials
 - a. ASTM C 450: Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments.
 - b. ASTM E 84: Standard Test Method for Surface Burning Characteristics of Building Materials
 - 3. Standards for field applied jackets and accessories
 - a. ASTM C 1729: Standard Specification for Aluminum Jacketing for Insulation.
 - b. ASTM D 1784: Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
 - c. ASTM B 209: Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

1.4 SUBMITTALS

- A. Material list: Each type of insulation and accessory, with manufacturer's name and material name and number. Identify locations for use, thickness of material, type of jacket, vapor barrier, and method of application.
- B. Product data: Sufficient to show that the product meets the specified requirements for materials, composition, and performance.
- C. Submit a single manufacturer for each product. Submittals that include multiple manufacturers for a single product are not acceptable.
- D. Installer qualifications.

1.5 QUALITY CONTROL SUBMITTALS

- A. Manufacturer's instructions: Recommended accessory materials and products; installation instructions.

1.6 QUALITY ASSURANCE

- A. Installers shall be mechanics skilled in this trade, employed with a firm that has a minimum of five years of experience installing mechanical insulation.

PART 2 - PRODUCTS

2.1 AVAILABLE MANUFACTURERS

- A. The listed manufacturers and particular products are intended to set a standard for materials, composition, and performance. Products of other manufacturers may be proposed as permitted by the provisions of Division 01 and the article "Product Options" in Section 23 0101.
- B. Flexible elastomeric insulation:
 - 1. Aeroflex USA*
 - 2. Armacell LLC*
 - 3. K-Flex USA
 - 4. Rubatex
 - 5. Or approved equal.
- C. Coatings, adhesives, and fabrics:
 - 1. Childers
 - 2. Foster
 - 3. Manville Building Materials Group
 - 4. Rock Wool Manufacturing Company
 - 5. Trimac
 - 6. Or approved equal.

2.2 FLEXIBLE ELASTOMERIC INSULATION MATERIALS

- A. Flexible elastomeric preformed pipe insulation: Closed-cell, sponge- or expanded-rubber, ASTM C 534, Type I for tubular materials. ASTM E 84 surface burning characteristics (flame spread/smoke developed) rating less than 25/50.

- B. Flexible elastomeric preformed fitting and valve covers: Closed-cell, sponge- or expanded-rubber, made from the same material and density as adjacent pipe insulation, meeting ASTM C 450 requirements for dimensions used in forming insulation to cover valves, elbows, tees, flanges, strainers, and unions. Provide with preformed PVC field-applied jacket. ASTM E 84 surface burning characteristics (flame spread/smoke developed) rating less than 25/50.
1. Where flexible elastomeric insulation is used on hot gas piping in VRF applications, insulation shall be tested in accordance with ASTM C411 at 250 degrees F (121 degrees C) for a 96 hour time period and shall meet an ASTM E 84 surface burning characteristic (flame spread/smoke developed) rating less than 25/50 at 2 inches (50 mm) of thickness.
- C. Flexible elastomeric insulation adhesive:
1. Water resistant contact cement designed especially suited for bonding two impermeable surfaces and recommended for rubber foam, steel, or aluminum surfaces, and compatible with service temperatures. ASTM E 84 surface burning characteristics (flame spread/smoke developed) rating less than 25/50.
 2. Basis of design: Foster 85-75 "Drion".
- D. Flexible Elastomeric Tape: Black, closed cell, self-adhering, elastomeric thermal insulation tape for insulating pipes and fittings, 0.125 inch (3 mm) thick, 2 inches (50 mm) wide, ASTM C 534, Type I — Grade 1. ASTM E 84 surface burning characteristics (flame spread/smoke developed) rating less than 25/50.
- E. Flexible elastomeric insulation vapor barrier coating:
1. Water-based latex enamel coating for use over flexible elastomeric insulation, providing a moisture-resistant protective finish suitable for both indoor and outdoor applications. ASTM E 84 surface burning characteristics (flame spread/smoke developed) rating less than 25/50.
 2. Basis of design: Armacell "WB Armaflex" latex enamel.

2.3 FASTENERS

- A. Aluminum bands: ASTM B 209, 0.75 inches (19 mm) wide and 0.020 inches (0.4 mm) thick.

2.4 FIELD-APPLIED JACKETS

- A. Polyvinyl chloride (PVC) jacket:
1. Jacket material: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; 20 mils (0.5 mm) thick; roll stock ready for shop or field cutting and forming. ASTM E 84 surface burning characteristics (flame spread/smoke developed) rating less than 25/50.
 2. Color: White.
 3. Adhesive: As recommended by jacket material manufacturer. ASTM E 84 surface burning characteristics (flame spread/smoke developed) rating less than 25/50.
 4. Fitting covers: Manufacturer's factory-fabricated fitting covers made from the same material, finish, and thickness as the jacket, suitable to the size of fittings and thickness of insulation. Provide factory fabricated fitting covers for elbows, tees, flanges, unions, reducers, end caps, valves, and other fittings. ASTM E 84 surface burning characteristics (flame spread/smoke developed) rating less than 25/50. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

5. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket and fitting covers with acrylic adhesive; suitable for indoor and outdoor applications, 2 inch (50 mm) width, 6 mil (0.15 mm) thickness. ASTM E 84 surface burning characteristics (flame spread/smoke developed) rating less than 25/50.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Provide interior piping insulation in accordance with the Minimum Insulation Thickness Schedule for Interior Applications at the end of this section, as modified by specifications for each location and type.
- B. Provide field applied jackets in accordance with the Field-Applied Jacket Schedule at the end of this section, as modified by specifications for each location and type.
- C. Provide flexible elastomeric insulation for refrigerant piping
- D. Apply insulation in a neat and workmanlike manner and in accordance with manufacturer's printed instructions.
- E. Maintain a continuous vapor barrier on systems that convey fluid at below-ambient temperatures, including the following applications:
 1. Refrigerant piping
- F. Where a continuous vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
- G. Installation at pipe hangers:
 1. Insulation shall be continuous through hangers for all piping systems.
 2. Install pipe covering protection shields with thickness of structural insulation inserts equal, under load, to that of adjoining insulation.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
 5. Shields and structural insulation inserts are specified in Section 23 0529, Hangers and Supports for HVAC Piping and Equipment.
- H. Where insulated piping systems pass through sleeves or openings in partitions and floors, the insulation shall be continuous through the sleeves and openings. See Firestopping specifications for coordinating insulation and firestopping.
- I. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- J. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- K. Install insulation with longitudinal seams at top and bottom of horizontal runs.

- L. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- M. Install insulation with least number of joints practical.
- N. Finish installation with systems at operating conditions. Repair separations and cracking caused by thermal movement.
- O. Return piping systems shall be insulated to meet the temperature demands of supply piping systems. There shall be no reduction of insulation thickness for anticipated temperature change between supply and return.

3.2 INSTALLING FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and circumferential joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Installation on fittings and flanges:
 - 1. Install insulation over fittings and flanges with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 - 2. Insulate using flexible elastomeric preformed fitting covers whenever possible. Install preformed fittings with adhesive. Tape and seal with vapor barrier coating.
 - 3. Where flexible elastomeric preformed fitting covers are not available, insulate using mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining pieces and bonded with adhesive. Tape and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated. Seal with vapor barrier coating.
 - 4. Install fitted PVC cover. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 - 5. Flanges: Install pre-formed pipe insulation to outer diameter of pipe flange. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation. Secure insulation to flanges and tape and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated. Seal with vapor barrier coating.

3.3 INSTALLING FIELD-APPLIED JACKETS

- A. Installing PVC jacket:
 - 1. Provide jacket tight to insulation.
 - 2. Provide with 1-inch (25-mm) overlap at longitudinal seams and circumferential joints.
 - 3. For horizontal applications, install with longitudinal seams along top and bottom of pipes.
 - 4. Seal with manufacturer's recommended adhesive. Apply two continuous beads of adhesive to seams and joints, one bead under the jacket lap and another finish bead along each seam and joint edge.
 - 5. Seams and joints shall completely prevent the entrance of water.

3.4 INSTALLING EXTERIOR PIPING INSULATION

- A. Locations: Provide insulation for piping systems exterior of building heated space, including but not limited to attics and unheated parking garages.

- B. Insulation: Material as specified for interior systems unless otherwise indicated, minimum 2 inches (50 mm) thick, or 0.5 inches (13 mm) thicker than scheduled for interior insulation on similar system, whichever is greater.
- C. Start insulation 30 inches (760 mm) below grade, 30 inches (760 mm) below roof or 30 inches (760 mm) inside exterior wall. Secure insulation with aluminum bands on 12-inch (305-mm) centers.

3.5 SCHEDULES

- A. Minimum insulation thickness schedule for interior heat pump refrigeration applications:

MINIMUM INSULATION THICKNESS SCHEDULE FOR INTERIOR HEAT PUMP REFRIGERATION APPLICATIONS (1)			
Application	Fluid Temperature Range	NPS 1.25 (DN 32) & Smaller	NPS 1.5 (DN 40) & Greater
Refrigerant Liquid	61F to 140F (16.1C to 60C)	1-inch (25 mm)	1.5-inch (38 mm)
Refrigerant Suction/Hot Gas (2)	61F to 140F (16.1C to 60C)	1-inch (25 mm)	1.5-inch (38 mm)
Refrigerant Hot Gas (3)	105F to 140F (40.6C to 60C)	1-inch (25 mm)	1.5-inch (38 mm)
(1) - See additional thickness requirements for exterior applications. (2) - For heat pump applications where piping may be either hot gas or refrigerant suction depending on the mode of operation, insulate the piping to meet the more demanding requirements of refrigerant hot gas. (3) - Hot gas may be required for split system hot gas reheat applications.			

- B. Field-applied jacket schedule:

FIELD-APPLIED JACKET SCHEDULE	
Application	PVC Jacket
Exterior applications	X
Pipe insulation exposed in mechanical rooms, penthouses, and other service areas not accessible to the public.	X

END OF SECTION

SECTION 23 2300

REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Refrigerant piping and accessories for equipment in related sections.

1.2 RELATED SECTIONS

- A. Piping materials and methods: Section 23 0500.
- B. Piping hangers and supports: Section 23 0529.
- C. Piping insulation: Section 23 0719
- D. Equipment:
 - 1. Ductless split-system units: Section 23 8127.
 - 2. Air-to-air packaged heat pump units: Section 23 8143.

1.3 REFERENCES

- A. Air Conditioning, Heating, and Refrigeration Institute
 - 1. AHRI 495: Performance Rating of Refrigerant Liquid Receivers
 - 2. AHRI 730: Flow Capacity Rating of Suction Line Filters and Suction Line Filter Driers
 - 3. AHRI 750: Thermostatic Refrigerant Expansion Valves
 - 4. AHRI 760: Performance Rating of Solenoid Valves for Use with Volatile Refrigerants
- B. American Society of Testing and Materials
 - 1. ASTM B 280: Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
 - 2. ASTM C 1427-07: Standard Specification for Extruded Preformed Flexible Cellular Polyolefin Thermal Insulation in Sheet and Tubular Form
- C. American Society of Mechanical Engineers/American National Standards Institute
 - 1. ASME/ANSI B16.22: Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings
- D. American Society of Refrigerating and Air-Conditioning Engineers
 - 1. ASHRAE Standard 15: Safety Standard for Refrigeration Systems
 - 2. ASHRAE Standard 34: Designation and Classification of Refrigerants
 - 3. ASHRAE Standard 147: Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems
- E. American Welding Society
 - 1. AWS A5.8/A5.8M: Specification for Filler Metals for Brazing and Braze Welding
- F. Society of Automotive Engineers

1. SAE J533: Flares for Tubing

G. UL

1. UL 429: Standard for Safety Electrically Operated Valves

1.4 DESIGN REQUIREMENTS

- A. Refrigerant piping shall be sized by the manufacturer of the refrigeration compressor, as specified in sections describing refrigeration equipment.
- B. Design pressures: Calculated in accordance with "System Design Pressure" in ASHRAE Standard 15.

1.5 SUBMITTALS

A. Product data:

1. Piping, fittings, brazing filler metal, brazing flux, and pipe joint compound.
2. Each type of valve, including materials, classifications, arrangement, dimensions and required clearances, and installation instructions.
3. Each type of device and accessory.

B. Shop drawings:

1. Pre-insulated tubing, including sizes and approximate lengths of lines.
2. Built-up system piping diagram, including sizes, details, and accessories.
3. Submit system design pressures for use in testing system. In accordance with the International Mechanical Code, "Field Test" for refrigeration systems, including the pressures listed on the condensing unit, compressor, or compressor unit nameplate, and the settings of pressure relief devices.

C. Certifications: Provide certificate of field tests in a form acceptable to the authority having jurisdiction, as part of the permit and inspection records. Certificate shall include no less than:

1. Name of refrigerant.
2. Field test pressure applied to high and low sides of the system.
3. Signature and printed name of the installer.

1.6 QUALITY ASSURANCE

- A. Pipe shall be certified by the manufacturer to meet referenced standards and shall bear a label, directly on the pipe, indicating compliance.

PART 2 - PRODUCTS

2.1 MATERIAL

- A. Refrigerant: R-410A.

2.2 PIPING (PRE-INSULATED TUBING)

- A. Refrigerant pipe:

1. Pre-insulated Type L soft drawn seamless copper tubing, ASTM B 280. Provide complete with factory-applied, closed-cell insulation and jacketing in accordance with ASTM C 1427-07, Type I, Grade I, suitable for a maximum operating temperature of 250 degrees F, and meeting the minimum insulation thickness requirements of Section 23 0719.
2. Basis of design: H Max pre-insulated copper line sets.

2.3 PIPE AND FITTINGS (BUILT-UP SYSTEMS)

- A. Refrigerant pipe: ASTM B 280 Type ACR hard-drawn seamless copper tubing.
- B. Fittings: Wrought copper, solder-joint type, ANSI B16.22.
- C. Brazing Filler Metals: AWS A5.8/A5.8M.
 1. Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
 2. Type BA9 (cadmium-free silver) alloy for joining copper with bronze or steel.
- D. Brazing Flux: Non-corrosive.
- E. Threaded pipe joint compound: Pipe joint compound recommended by the manufacturer for use at the temperature and pressure of the system.
- F. Threaded pipe joint tape: Polytetrafluoroethylene (PTFE) pipe thread tape, "Teflon."

2.4 ACCESSORIES (BUILT-UP SYSTEMS)

- A. System: Provide the listed accessories as a minimum on each built-up system, in accordance with approved shop drawings and as recommended by the refrigeration equipment manufacturer. Accessories provided by the equipment manufacturer with the equipment are acceptable.
- B. Isolation valves:
 1. Forged brass body ball valve.
 2. Full port.
 3. Extended copper connections suitable for brazing.
 4. Brass ball.
 5. Polytetrafluoroethylene PTFE seals, "Teflon".
 6. Vented ball cavity.
 7. Blow out proof stem.
 8. Double O-ring stem seals.
 9. Positive shut-off in both directions.
 10. Factory tested.
 11. UL listed.
 12. Working Pressure Rating: 500 psig (3450 kPa).
 13. Maximum Operating Temperature: 275 degrees F (135 degrees C).
- C. Check valves:
 1. Body: Forged brass, or cast bronze; globe pattern.
 2. Bonnet: Bolted forged brass, or cast bronze; or brass hex plug.
 3. Piston: Removable polytetrafluoroethylene seat.
 4. Closing Spring: Stainless steel.
 5. End Connections: socket or threaded.
 6. Maximum Opening Pressure: 0.50 psig (3.4 kPa).
 7. Working Pressure Rating: 500 psig (3450 kPa).

8. Maximum Operating Temperature: 275 deg F (135 deg C).

D. Service valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig (3450 kPa).

E. Solenoid Valves:

1. Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory.
2. Body and Bonnet: Plated steel.
3. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
4. Seat: Polytetrafluoroethylene.
5. End Connections: Threaded.
6. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and a coil compatible with the control signal and available power.
7. Working Pressure Rating: 500 psig (3450 kPa).
8. Maximum Operating Temperature: 240 degrees F (116 degrees C).

F. Safety Relief Valves:

1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by a National Recognized Testing Laboratory.
2. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
3. Piston, Closing Spring, and Seat Insert: Stainless steel.
4. Seat: Polytetrafluoroethylene.
5. End Connections: Threaded.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 240 degrees F (116 degrees C).

G. Thermostatic Expansion Valves:

1. Comply with AHRI 750.
2. Body, Bonnet, and Seal Cap: Forged brass or steel.
3. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
4. Packing and Gaskets: Non-asbestos.
5. Capillary and Bulb: Copper tubing filled with refrigerant charge.
6. Suction Temperature: 40 degrees F (4.4 degrees C).
7. Superheat: Adjustable.
8. Provide reverse-flow option for heat-pump applications.
9. End Connections: Socket, flare, or threaded.
10. Working Pressure Rating: 500 psig (3450 kPa).

H. Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig (3450 kPa).

6. Maximum Operating Temperature: 275 degrees F (135 degrees C).

I. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in parts per million (ppm).
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 240 degrees F (116 degrees C).

J. Filter Dryers:

1. Comply with AHRI 730.
2. Replaceable-core.
3. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
4. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
5. Desiccant Media: Activated alumina and activated charcoal.
6. Provide units designed for reverse flow for heat-pump applications.
7. End Connections: Socket.
8. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
9. Maximum Pressure Loss: 2 psig (14 kPa).
10. Working Pressure Rating: 500 psig (3450 kPa).
11. Maximum Operating Temperature: 240 degrees F (116 degrees C).

K. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
4. Working Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
5. Maximum Operating Temperature: 250 degrees F (121 degrees C).

L. Mufflers:

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig (3450 kPa).
4. Maximum Operating Temperature: 275 degrees F (135 degrees C).

M. Receivers:

1. Comply with AHRI 495.
2. Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
3. Comply with UL 207; listed and labeled by an NRTL.
4. Body: Welded steel with corrosion-resistant coating.
5. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
6. End Connections: Socket or threaded.
7. Working Pressure Rating: 500 psig (3450 kPa).

8. Maximum Operating Temperature: 275 degrees F (135 degrees C).

N. Liquid Accumulators:

1. Comply with AHRI 495.
2. Body: Welded steel with corrosion-resistant coating.
3. End Connections: Socket or threaded.
4. Working Pressure Rating: 500 psig (3450 kPa).
5. Maximum Operating Temperature: 275 degrees F (135 degrees C).

PART 3 - EXECUTION

3.1 INSTALLATION (GENERAL)

- A. Install piping as indicated on the drawings and in accordance with provisions of Section 23 0500 and the piping system application article at the end of Part 3.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Actual size and configuration of refrigerant piping shall be in conformance with the recommendations of the refrigeration equipment manufacturer.
- C. Install refrigerant piping according to ASHRAE Standard 15.
- D. Hang horizontal piping NPS 2 (DN 50) and smaller using a metal framing system, clamps, and insulation inserts in accordance with Section 23 0529. For pre-insulated tubing systems, remove section of factory-applied insulation at metal framing system and provide specified clamps and insulation inserts. Seal ends of piping insulation and inserts in accordance with manufacturer's instructions.
- E. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- F. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls.
- G. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- H. Install piping adjacent to machines to allow service and maintenance.
- I. Install piping free of sags and bends.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- L. Arrange piping to allow inspection and service of refrigeration equipment.
- M. Install valves and specialties in accessible locations to allow for service and inspection.
- N. Slope refrigerant piping as follows:
 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.

2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

- O. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

3.2 INSTALLATION (PRE-INSULATED TUBING)

- A. Install piping and seal ends of piping insulation as shown on drawings and in accordance with manufacturer's instructions and approved shop drawings.

3.3 INSTALLATION (BUILT-UP SYSTEM)

- A. Install piping as shown on drawings and in accordance with manufacturer's instructions and approved shop drawings.

B. Brazed joints:

1. Install piping with brazed joints where possible.
2. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation. To permit flow and to avoid pressure build-up, make sure one end of the pipe is open.

C. Flared fittings:

1. Install piping with flared joints where required for connections.
2. Flare joints shall conform to SAE J533.

D. Threaded joints:

1. Install piping with threaded joints where required for connections.
2. Make threaded connections with pipe joint compound approved for the service, or "PTFE" tape.

E. Isolation valves:

1. Provide isolation valves in suction and discharge lines of compressors.
2. Provide isolation valves on inlet and outlet side of filter dryers. Provide an additional isolation valve and pipe and fittings to bypass the filter dryer.

- F. Check valves: Install a check valve at the compressor discharge.

G. Service valves:

1. Provide service valves to enable pressure testing, refrigerant charging, and system evacuation.
2. Provide service valves between isolation valves and compressor suction connections if they not an integral part of the isolation valves or compressor equipment.
3. Provide service valves for gage taps at inlet and outlet of strainers if they are not an integral part of valves and strainers.

H. Solenoid valves:

1. Provide solenoid valves upstream from each expansion valve.
 2. Provide solenoid valves in horizontal lines with coil at top.
- I. Safety relief valves:
1. Install safety relief valves where required by the ASME Boiler and Pressure Vessel Code.
 2. Vent safety relief valves to the atmosphere in accordance with ASHRAE Standard 15 and ASHRAE Standard 34.
- J. Thermostatic expansion valves:
1. Provide thermostatic expansion valves as close as possible to distributors on evaporators.
 2. Install valve so diaphragm case is warmer than bulb.
 3. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 4. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- K. Strainers: Provide strainers upstream from and adjacent to solenoid valves and thermostatic expansion valves, unless they are furnished as an integral assembly for the device being protected.
- L. Moisture/Liquid Indicators: Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- M. Filter driers: Provide filter dryers in liquid line between compressor and thermostatic expansion valve.
- N. Flexible connectors: Provide flexible connectors at compressor connections.
- O. Muffler: Provide muffler on the discharge side of the compressor, between the flexible connector and the condenser.
- P. Receivers: Provide receivers sized to accommodate pump-down charge.
- Q. Liquid accumulators: Provide liquid accumulator at compressor suction.
- 3.4 LEAK TEST
- A. After the refrigeration systems have been installed, perform a leak test before evacuating the systems.
1. The cylinder of oil-pumped nitrogen shall be equipped with a shutoff valve, pressure reducing valve, cylinder pressure gauge, line pressure gauge, and bleed valve.
- B. Remove controls or relief valves which could be damaged by test pressures.
- C. Separate the high side from the low side and bleed in enough refrigerant to raise the system pressure to 12 to 15 psig (83 to 103 kPa). Then, using oil-pumped dry nitrogen, raise the pressures to the test pressures established as required in "Submittals" in Part 1 above.
- D. Test the entire system for leaks.

- E. Bleed off the pressure into cylinders, in accordance with ASHRAE Standard 147, and repair leaks. Do not attempt to repair a leak while the system is under pressure. Do not repair bad joints by remelting and adding more brazing material. Take joint apart, thoroughly clean, and remake as a new joint.
- F. Retest the system if a leak is found.
- G. When tests and repairs are complete, replace valves or controls removed for protection.
- H. Submit test certificate required in "Submittals" in Part 1 above.

3.5 EVACUATION

- A. To evacuate the system, use a vacuum pump capable of producing at least 1 mm (0.039 inches) mercury absolute vacuum. Proceed as follows:
 - 1. Connect an accurate high vacuum gauge (Micron), such as a Stoke's or Zimmerli gauge, to the system. Do not use compound gauges.
 - 2. Connect the vacuum pump to both the high and low sides of the system. Leave the compressor suction and discharge valves closed. Evacuate the system to 2.5 mm (0.098 inches) mercury absolute. Keep ambient air temperatures above 60 degrees F (15.6 degrees C) during the evacuation process.
 - 3. Break the system vacuum with oil-pumped dry nitrogen. Open the compressor suction and discharge service valves and re-evacuate the system to 2.5 mm (0.098 inches) mercury absolute.
 - 4. After the system has been double evacuated to 2.5 mm (0.098 inches) mercury absolute, close the vacuum-pump suction valve and stop the pump. Allow the system to stand under a vacuum a minimum of 12 hours and recheck the vacuum. Notify the DGS Project Manager in time for him to verify the test pressure at beginning and end of time limit, before proceeding to charge the system.

3.6 CHARGING

- A. Charge the system with refrigerant through the liquid-line charging valve. Use a clean strainer-drier in the charging line, along with a pressure gauge and shut-off valve to control pressures. Before starting the compressor, ascertain that the oil sight glass, if provided, is 75 percent full, and suction and discharge valves back-seated.

3.7 FINAL START-UP PROCEDURE

- A. Check out operating and safety controls in accordance with the compressor manufacturer's recommendations.
- B. Recheck the oil level in the sight glass at frequent intervals. It should not drop below 50 percent level.
- C. Adjust compressor suction unloaders, if provided, for proper evaporator-compressor balance to maintain the scheduled minimum discharge temperature.
- D. Reinspect the system after it has been in normal operation for at least 72 hours. At this time, instruct the Government's designated personnel in the operation and maintenance of the equipment, as required in the equipment section.

3.8 LUBRICATION

- A. If it becomes necessary to add oil to the system, use only the oil recommended by the compressor manufacturer.

3.9 PIPING SYSTEM APPLICATIONS

- A. Provide built-up piping or pre-insulated piping for the following equipment as indicated:
 - 1. Equipment:
 - a. Air-to-air packaged heat pump units
 - b. Ductless split-systems
 - 2. Piping NPS1 (DN 25) and larger shall be built-up piping.
 - 3. Piping smaller than NPS 1 (DN 25) may be built-up piping or pre-insulated tubing.

END OF SECTION

SECTION 23 3113

METAL DUCTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. HVAC metal supply, return, and exhaust ductwork and plenums in pressure classes from -2 to +10 inches w.g. (-500 to +2490 Pa).
- B. Shop-fabricated or factory-fabricated ducts and fittings: Single-wall round duct.
- C. Joint and sealing materials.
- D. Air duct leakage testing.

1.2 RELATED SECTIONS

- A. Duct identification: Section 23 0500.
- B. Balancing: Section 23 0593.
- C. Insulation: Section 23 0713.
- D. Duct hanging: Section 23 3114.
- E. Duct accessories: Section 23 3300.
- F. Flexible ducts: Section 23 3346.

1.3 REFERENCES

- A. ACGIH-01: American Conference of Governmental Industrial Hygienists
 - 1. Industrial Ventilation: A Manual of Recommended Practice.
- B. ASHRAE
 - 1. ASHRAE Handbook of Fundamentals.
- C. ASTM
 - 1. ASTM C 423: Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
 - 2. ASTM C 1071: Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Material).
 - 3. ASTM D 1330: Rubber Sheet Gaskets.
 - 4. ASTM E2336: Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems
 - 5. ASTM G 21: Determining Resistance of Synthetic Polymeric Materials to Fungi.
 - 6. ASTM G 22: Determining Resistance of Synthetic Polymeric Materials to Bacteria.
- D. SMACNA
 - 1. HVAC DCS: SMACNA HVAC Duct Construction Standards, Metal and Flexible.
 - 2. RIDCS: SMACNA Round Industrial Duct Construction Standards.

3. HVAC Air Duct Leakage Test Manual.

E. UL 181: Factory-Made Air Ducts and Air Connectors.

1.4 DEFINITIONS

- A. Seam: Joining of two longitudinal (parallel to the direction of airflow) edges of duct surface material. All other duct surface connections are joints.
- B. Joints: Transverse joints (perpendicular to the direction of airflow); branch and subbranch intersections; duct collar tap-ins; louver and air terminal connections to ducts; access door and access panel frames and jambs; duct, plenum, and casing abutments to building structures.

1.5 SYSTEM PERFORMANCE REQUIREMENTS

- A. The duct system design, as indicated, has been used to select and size air moving and distribution equipment and other components of the air system. Do not change the layout or configuration of the duct system except as specifically approved in writing. Accompany requests for modifications with calculations showing that the proposed design will provide the original design results without increasing system total pressure.

1.6 SUBMITTALS

- A. Shop drawings:
1. Schedule of duct systems with applicable pressure classes and leakage classes.
 2. Fabrication, assembly, and installation for each duct system: Indicate duct dimensions, sheet metal thickness, reinforcement spacing, and seam and joint construction; and components and attachments to other work.
 3. Calculations required as specified in the article "System Performance Requirements" above.
 4. Include layout drawings for the entire ductwork system, drawn at the same scale as the contract drawings, except no smaller than 0.125 inch equals one foot.
 5. Schedule of sealing methods for each type of seam and joint.
- B. Product data:
1. Factory-fabricated ducts and fittings.
 2. Joint and sealing materials.
 3. Manufacturer's installation instructions.
- C. Test reports: Air Duct Leakage Test Summary: Submit data on forms as indicated in the SMACNA HVAC Duct Leakage Test Manual. (See sample form at end of section.)

1.7 QUALITY ASSURANCE

- A. Specified and scheduled duct construction exceeds SMACNA requirements. Comply with specifications and schedules, and for materials or methods not specified or scheduled, comply with SMACNA HVAC DCS and RIDCS.
- B. Comply with NFPA 90A and 90B.
- C. Where shop-fabricated ductwork and fittings are permitted, products shall meet or exceed the quality of material, quality of construction, and performance of the basis of design factory-fabricated product.

- D. Where shop-fabricated ductwork and fittings are proposed, contractor shall provide a listing of ten comparable projects completed within the last five years using shop-fabricated ductwork and fittings of the type proposed as evidence of quality and performance.

PART 2 - PRODUCTS

2.1 AVAILABLE MANUFACTURERS

- A. Basis-of-design products: Subject to compliance with requirements, provide specified or noted products, or comparable product by one of the following:

1. Factory-fabricated ducts and fittings:

- a. Eastern Sheet Metal
- b. Hamlin Sheet Metal
- c. LaPine Metal Products
- d. Linx Industries
- e. McGill Airflow Corp.
- f. MKT Metal Manufacturing
- g. Phoenix Metals
- h. Semco Mfg. Inc.
- i. SPIRAmir
- j. Or approved equal.

2. Manufactured joint connectors:

- a. Ductmate Industries
- b. C.L. Ward & Family Inc.
- c. Or approved equal.

- B. Special use ducts and fittings: Scheduled manufacturers and named products are intended to set a standard for materials, quality of construction, and performance.

2.2 MATERIALS

- A. Metal sheets:

1. Galvanized steel sheets: Lock-forming quality, ASTM A 653/A 653M, coating designation G90 (Z275).

- B. Tie rods: Galvanized steel, minimum diameter 0.25 inch (6 mm) for ducts up to 36 inches (900 mm); 0.375 inch (9 mm) for ducts over 36 inches (900 mm).

2.3 SHOP-FABRICATED OR FACTORY-FABRICATED DUCTS AND FITTINGS

- A. Single-wall, rectangular duct and fittings:

1. Fabricate according to SMACNA HVAC DCS.

- B. Single-wall, flat lock longitudinal-seam round duct and fittings:

1. Fabricate according to SMACNA HVAC DCS.
2. Seam: Flat lock; snap-lock seam not permitted.

- C. Single-wall, spiral round duct and fittings for concealed applications: Provide the following construction unless otherwise indicated for special applications,
1. Material: Galvanized steel.
 2. Seams: Spiral lock seam.
 3. Joint basis of design: Round fittings, McGill Airflow "Uni-Seal" fittings, lap and riveted/screwed and sealed.
 4. Fittings for branch connections shall be conical type.
 5. Centerline radius of elbows shall be 1.5 times the diameter.
 6. Duct access door basis of design: Type AR-W.
 7. Basis of Design: McGill Airflow "Uni-Seal" spiral duct with "Uni-form" fittings.

2.4 JOINT AND SEALING MATERIALS

- A. Flexible joint material for connections to vibrating equipment: Specified in Section 23 3300, Duct Accessories.
- B. Duct joint and seam sealants: UL classified, fire-resistive, conforming to NFPA 90A and 90B, high pressure type (up to 10 inches (2490 Pa) SMACNA pressure class), the following products are the basis of design:
1. Indoor application: Hardcast "Iron Grip" (IG-601) brush-on water-based vinyl acrylic sealing mastic.
 2. Flange gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

PART 3 - EXECUTION

3.1 COORDINATION

- A. Before fabricating ductwork, make field measurements and coordinate layout of ductwork shown on the drawings with building components and work of other trades. Resolve conflicts and obtain written approval for deviations before fabrication or buying ductwork.
- B. Provide for and install control dampers, manual volume dampers, backdraft dampers, smoke dampers, thermometers, coils, sound attenuators, duct accessories and similar equipment furnished under this or other sections of the specifications.
- C. Coordination with other work:
1. Wall, partition, ceiling, and floor penetrations:
 - a. Penetrations with fire dampers, smoke dampers, or fire/smoke dampers: Connect ductwork to the damper in accordance with the damper listing after the damper installation is complete. Do not install the ductwork through the wall.
 - b. Penetrations with fire dampers, smoke dampers, or fire/smoke dampers:
 1. Fill void between the architectural element and the duct with mineral wool.
 2. Provide metal trim angles around the perimeter of the rectangular duct.
 3. Provide a slip on flange around the perimeter of round or flat oval ducts.
 2. Exterior wall penetrations: Flash ducts passing through exterior walls as detailed on the drawings.
 3. Louvers: Slope ductwork down toward the louver. Provide connections as indicated below:

- a. Ductwork connection full size of louver: Provide angles, flanges, or damper collars as required to connect the ductwork to the louver.
 - b. Ductwork connections smaller than the full size of the louver: Blank off any unused portion of the louver with double-wall insulated metal panels with metal faces constructed of the same material as the connecting duct, and 1.5 inch (38 mm) thick minimum fiberglass insulation. Seal edges of panel insulation with sheet metal channels. Connect ductwork to insulated metal panel with using angles or flanges.
 - c. Damper connection to louver: Provide metal angle or channel frames as required for mounting ATC dampers and manual dampers to louvers.
4. Electrical panels and equipment:
- a. Do not install ductwork over electrical panels and equipment unless otherwise indicated.
 - b. Where ductwork must be installed over electrical panels and equipment, provide aluminum sheet metal drain troughs under piping with drains piped to a safe location.
5. Accessories with frames: Where ATC dampers and other accessories with frames are mounted in ductwork, connect ductwork to frames in a manner to provide 100 percent free area for air passage. Seal ductwork connections to frames with gaskets or duct sealant. Secure connections with pop rivets or sheet metal screws spaced no more than 3 inches (75 mm) on centers around both sides of entire frame.

3.2 INSTALLING METAL DUCTWORK

- A. Dimensions indicated on drawings are outer dimensions of ducts. Dimensions indicated for double-wall ducts are outer dimensions of outer wall.
- B. Construct ductwork using the Duct Construction Schedule on the drawings. Schedule includes duct system pressure class requirements, minimum sheet metal gauges, leakage allowances, and maximum reinforcement spacing. These requirements exceed the requirements of SMACNA HVAC DCS. Engineered duct systems using metal gauges or reinforcing less than required in the schedules on the drawings are not acceptable.
- C. Material: Construct ductwork of galvanized steel, except where another material is noted on drawings or specified.
- D. Joints: Provide one of the following duct joints, except where other criteria are noted on the drawings or specified. Snap-lock or flat-lock seams are not acceptable.
 1. Joint connections constructed in accordance with SMACNA HVAC DCS,
 2. Manufactured duct connection system basis of design: Ductmate Industries "Ductmate," selected to assure compliance with leakage factors indicated on the drawings.
- E. Where specific materials and seam and joint construction are specified for a specific application, all ductwork carrying any concentration of air for that application, no matter how dilute, shall be constructed according to the requirements of the application.
- F. Provide duct systems complete with built-in accessories as specified herein, in other sections of the specifications, as indicated on the drawings, and, where not otherwise indicated, in accordance with SMACNA HVAC DCS.
- G. Thoroughly clean duct and duct fittings before they are installed, and keep them clean until the acceptance of the completed work. Use a duct cap cover on all unfinished ends to prevent moisture, dirt particles, dust, and debris from entering the installed ductwork during construction.

- H. Install metal ductwork neat in appearance. Interior surfaces shall be smooth and free of obstructions. Duct lines shall be true and smooth.
- I. Contractor has the option to eliminate reducing transitions and extend ductwork full size, providing space is available and conflict with work of other trades does not occur.
- J. Make bends and turns in ductwork using offsets and curved or square elbows as indicated on the drawings. Provide full radius elbows (centerline radius equals 1.5 times duct width). Provide turning vanes in square elbows. Make 90-degree branch duct connections using 45-degree entry fittings unless otherwise indicated.
- K. Generally, it is intended that horizontal ductwork be a minimum of 10 inches (255 mm) above suspended ceiling (where applicable) to allow removal of ceiling panels and ceiling-mounted light fixtures and devices. Coordinate duct installation to achieve that clearance wherever possible.
- L. Unless otherwise indicated, exposed ductwork shall be mounted as high as possible.
- M. Brace large ductwork connected to fans and air handling units with metal angles to prevent vibration and duct damage, and to reduce noise.
- N. Construct gravity duct systems (nonfan-powered), such as pressure relief ducts and transfer ducts, in accordance with SMACNA HVAC DCS minimum one inch pressure class unless otherwise scheduled.
- O. Cross break or bead ducts of dimensions of 12 inches (305 mm) and over in pressure classes under 2 inches (500 Pa).
- P. Where ducts will be exposed, remove labels and clean surfaces. Where required, prepare surface for painting.
- Q. Single-wall plenums, casings, and access doors: Construct in accordance with SMACNA HVAC DCS.

3.3 INSTALLING ROUND DUCT

- A. Provide round single-wall and double-wall ductwork where indicated on plans.
- B. Assemble spiral round ducts and fittings using duct sealant and sheet metal screws as recommended by the manufacturer.
- C. Single-wall ductwork:
 - 1. Exposed: Spiral round duct and fittings unless otherwise indicated.
 - 2. Pressure class 3.0 inches w.g. or greater: Spiral round duct and fittings unless otherwise indicated.
 - 3. Serving other than a single diffusers: Spiral round duct and fittings unless otherwise indicated.
 - 4. Concealed, pressure class of 2.0 inches w.g. or less and serving a single air outlet: Longitudinal-seam duct and fittings.

3.4 SEALING DUCTWORK

- A. Seal all longitudinal and transverse joints, seams, and connections with the following exceptions:

1. Sealant may be omitted from welded joints and seams provided duct leakage is within the required tolerance.
 2. Sealant may be omitted from locking-type joints and seams (other than snap-lock and button-lock) in ductwork with a pressure class below 2 inches of water column (500 Pa) where permitted by code requirements and provided duct leakage is within the required tolerance.
- B. Sealing leakage performance: Seal ductwork to meet duct leakage factors scheduled on the drawings.
- C. Sealing procedures:
1. Prior to sealing, ductwork shall be clean and dry, free of oil or grease.
 2. Apply sealant in accordance with the manufacturer's recommendations.
 3. Allow time for sealant to dry or cure, in accordance with manufacturer's recommendations, before leak testing.
- D. Sealant material:
1. Galvanized steel ductwork: Brush-on or pressure sensitive sealant, as applicable.

3.5 AIR DUCT LEAKAGE TESTS

- A. Continuously examine ductwork during construction to ascertain that it is sealed properly.
- B. General test procedures:
1. Leakage test procedures shall be in accordance with SMACNA Leakage Test Manual.
 2. After installation and prior to insulating, test all ductwork for air leakage. Ducts to be tested, test pressures, and leakage factors (maximum volume of leakage per 100 square foot (9.3 square meter) of duct surface area) shall be as scheduled on the drawings.
 3. The ductwork quantity to be tested exceeds SMACNA leakage test manual recommendations.
 4. Conduct tests before any equipment is connected that would be subject to damage from the test pressure. Provide temporary blank-offs or caps.
 5. Notify parties whose presence is necessary for the test; and in all cases, the Architect and testing and balancing subcontractor in writing at least two normal work days prior to the actual test.
 6. While system is under test pressure, survey joints for audible leaks. Mark leakage points, shut down blower, and make repairs. Retest after duct sealant has dried or cured.
 7. If test duct sections exceed the allotted leakage levels, locate sources of leakage, make repairs and repeat test procedures until acceptable leakage levels are demonstrated.

END OF SECTION
Leakage test form follows Section

SECTION 23 3114

HANGERS AND SUPPORTS FOR DUCTWORK

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Duct hangers and supports.
- B. Trapeze duct hangers.
- C. Fasteners.

1.2 RELATED SECTIONS

- A. HVAC Duct Insulation: Section 23 0713.

1.3 REFERENCES

- A. ASTM International
 - 1. ASTM A 307: Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
 - 2. ASTM F 3125: Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated
- B. American Welding Society
 - 1. AWS-D.1.1: Structural Welding – Steel
- C. Metal Framing Manufacturer's Association
 - 1. MFMA-4: Metal Framing Standards Publication
 - 2. MFMA-103: Guidelines for the Use of Metal Framing
- D. Manufacturer's Standardization Society
 - 1. MSS SP-58: Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.
- E. SMACNA
 - 1. HVAC Duct Construction Standards - Metal and Flexible

1.4 SUBMITTALS

- A. Product data:
 - 1. Provide manufacturer's literature showing compliance with specifications for each type of framing system, fastener and accessory materials.
 - 2. Provide a schedule of building attachment types and associated attachment hardware and methods.

PART 2 - PRODUCTS

2.1 HANGERS AND SUPPORTS

- A. General: Comply with requirements of SMACNA's HVAC Duct Construction Standards - Metal and Flexible.
- B. Threaded rod: Continuously threaded, size and spacing in compliance with SMACNA's HVAC Duct Construction Standards - Metal and Flexible.
 - 1. Zinc-plated or galvanized carbon steel for indoor applications.
 - 2. Stainless steel for outdoor and corrosive applications.
- C. Nuts and washers: Provide the same material used for threaded rods.
- D. Straps: Match duct material, size and spacing in compliance with SMACNA's HVAC Duct Construction Standards - Metal and Flexible.
- E. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
 - 3. Supports for Aluminum Ducts: Aluminum, or galvanized steel coated with zinc chromate, shapes and plates.
- F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

2.2 FASTENERS

- A. Mechanical expansion anchors:
 - 1. Self-drilling type expansion shields or machine bolt drop-in anchors for drilled holes. Fasteners to floor slabs shall be vibration and shock resistant. Load applied to fasteners shall not exceed 25 percent of manufacturer's stated load capacity in 3500 psi (24,000 kPa) concrete. Provide zinc-coated anchors for indoor applications and stainless-steel anchors for outdoor applications.
 - 2. Basis of design: ITT Phillips Anchors "Red Head."
- B. Fasteners to wood construction: Lag bolts.
- C. Bolts, nuts, and washers: ASTM A 307, or ASTM F 3125 where high strength is required.

PART 3 - EXECUTION

3.1 GENERAL

- A. Comply with SMACNA's HVAC Duct Construction Standards - Metal and Flexible.
- B. Provide hangers, supports, fasteners, and attachments as required to properly support ductwork from the building structure.
- C. Provide supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

- D. Hanger Spacing: Comply with SMACNA's HVAC Duct Construction Standards - Metal and Flexible for maximum hanger spacing. Provide hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1220 mm) of each branch intersection.
- E. Where required, provide structural steel shapes or metal framing system channels and hardware to transfer load from a support location to multiple locations in the structure in order to get support from an appropriate location or to increase the strength of the connection to the structure.
- F. Support horizontal rectangular ductwork from above with trapeze hangers and threaded rod or straps where possible, unless otherwise indicated.
 - 1. Ducts 54 inches (1370 mm) wide and under:
 - a. Support with trapeze hangers or straps.
 - b. Strap hangers, where used, shall extend down sides of ducts and attach to underside with at least two sheet metal screws per strap.
- G. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).
- H. Fabricate wall-mounted and floor-mounted supports using metal framing systems or structural steel where required.
- I. Trim threaded rods with a maximum excess length of 1 inch (25 mm). Provide protective rubber red end caps on the ends of threaded rods exposed and within 8 feet (2.4 meters) of the floor, roof, or grade below.
- J. Install lateral bracing to prevent swaying.
- K. Install supports so that duct loads not be transmitted to connected equipment.
- L. Provide trapeze hangers where required to hang ductwork using threaded rod.
 - 1. Weld steel according to AWS D-1.1.
 - 2. Hang with threaded rods.
 - 3. Design trapeze hangers and supports based on supported load plus a 50 percent minimum safety factor.

3.2 BUILDING ATTACHMENTS:

- A. Attaching to concrete slabs and composite slabs:
 - 1. Obtain approval from the structural engineer and confirm allowable loads prior to supporting ductwork from concrete slabs or composite slabs. Where approved, provide one of the following as required:
 - a. Mechanical expansion anchors and steel bolts or rods.
 - b. Screws designed for attachment to concrete.
 - c. Powder actuated fasteners.
- B. Attaching to wood construction:
 - 1. General: Obtain approval from the structural engineer and confirm allowable loads prior to supporting ductwork from wood beams. Where approved, provide lag bolts.

2. Trusses: Follow roof truss manufacturers' recommendations for attachment locations, loads, spacing, and methods of attachment.
3. Joists: Provide MSS SP-58 Type 34 side beam connectors.

END OF SECTION

SECTION 23 3300

DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Flexible joint fabric.
- B. Bird screen.
- C. Air turning vanes.
- D. Spin-in fittings.
- E. Duct access doors.
- F. Dampers.
- G. Duct clamps.

1.2 RELATED SECTIONS

- A. Access doors: Division 08.
- B. Diffusers, registers, and grilles: Section 23 3713.

1.3 REFERENCES

- A. AMCA 210: Laboratory Methods of Testing Fans for Rating.
- B. ASTM E 477: Test for Measurement of Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.
- C. ASTM E 2016: Standard Specification for Industrial Woven Wire Cloth.
- D. NFPA 90A: Installation of Air Conditioning and Ventilating System.
- E. NFPA 90B: Installation of Warm Air Heating and Air-Conditioning Systems.
- F. NFPA 701: Standard Methods of Fire Tests for Flame Propagation of Textiles and Films
- G. SMACNA-05: Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems.
- H. SMACNA HVAC DCS: HVAC Duct Construction Standards, Metal and Flexible.

1.4 SUBMITTALS

- A. Product data: Each type of duct accessory included in the project.
- B. Shop drawings: Detail equipment assemblies and indicate dimensions, loadings, required clearances, method of field assembly, components, locations, and size of each field connection. Detail these accessories:

1. Special fittings and manual and automatic volume damper installations.

C. Certifications: Certified test data for dynamic insertion loss; sound power levels; airflow performance data, and static pressure loss.

1.5 QUALITY ASSURANCE

A. Work of this section shall comply with NFPA 90A and 90B, and SMACNA HVAC DCS.

PART 2 - PRODUCTS

2.1 AVAILABLE MANUFACTURERS

A. Manufacturers' names and specific products are described in the articles below to set a standard for materials, quality of construction, options and details, and performance. Provide named products, or equal products by other manufacturers.

2.2 FLEXIBLE CONNECTIONS

A. Flexible joint fabric: Woven glass fabric with coating, complying with NFPA 701 for fire retardance and NFPA 90A for use in duct systems.

1. For use indoors:

- a. Coated with polychloroprene (DuPont "Neoprene"), 30 ounces per square yard (850 g per 0.8 square meter).
- b. Basis of design: Ventfabrics "Ventglas."

2.3 SCREENS

A. Bird screen: ASTM E 2016, general industrial-use wire cloth, Grade C, medium light or heavier, nominal 0.5-inch (13-mm) mesh and 0.063-inch (1.6-mm) wire diameter, aluminum or stainless steel.

1. Frame: Removable, rewirable, of same material and finish as the duct or accessory to which it is installed.

2.4 MANUFACTURED UNITS

A. Air turning vanes: Double vane type, constructed in accordance with SMACNA HVAC DCS, from the same material as the duct.

B. Spin-in fittings in accordance with SMACNA HVAC DCS are acceptable for a round take-off connection from a rectangular duct, provided they meet the duct pressure classification.

2.5 DUCT ACCESS DOORS

A. SMACNA standard construction. Access doors to fire protection devices shall comply with NFPA 90A.

B. Construction: Door and frame fabricated of 24 gauge galvanized steel, minimum size 16 inches (406 mm) by 16 inches (406 mm), or 16 inches (406 mm) by maximum duct size.

- C. Door: Hinged with continuous piano hinge; number of cam latches to suit door size. Insulated doors shall be double pan construction, one inch (25 mm) thick with one inch (25 mm) thick minimum 3.5 pound (56 kg per cubic meter) density fiberglass insulation cut full to require forcing into the pan.
- D. Gaskets: Continuous around perimeter, sealing frame to duct and door to frame, neoprene or foam rubber.
- E. As an option, provide round access doors, complete with safety holding cable, 12 inches (305 mm) diameter.
- F. Basis of design:
 - 1. Square or rectangular access doors: Air Balance, Inc., Model FSA-100-H or equal by Ruskin, Inc., Airstream Products Company, Inc., or Commercial Acoustics.
 - 2. Round access doors: Ventfabrics "Ventlok Twist-In."

2.6 DUCT ACCESS DOORS – ROUND

- A. Sandwich style access door, insulated or uninsulated to match ductwork, metal material to match ductwork interior and exterior, rated for operation at pressures up to positive 20 inches w.g. (5,000 Pa) and down to negative 10 inches w.g. (2,500 Pa), threaded fasteners with rotating handles to draw inner and outer pieces of the door together.

2.7 DAMPERS

A. Material

- 1. Where aluminum duct is required by the specifications, dampers shall be all aluminum construction in lieu of galvanized steel.
- 2. Where stainless steel duct is required by the specifications, dampers shall be all stainless-steel construction in lieu of galvanized steel.

B. Manual volume dampers:

- 1. 13 inches (330 mm) and larger in height: Balanced multi-louver, opposed-blade type with maximum blade width of 8 inches (205 mm), with corrosion resistant, molded synthetic sleeve type bearing and 0.375-inch (9.5-mm) square control shaft; and with damper regulators designed with 2-inch-high base for mounting on externally insulated duct.
 - a. Basis of design:
 - (1) Damper: Ruskin Model MD 35.
 - (2) Regulator: Young Regulator Co. Model No. 443B-3/8.
- 2. 12 inches (305 mm) or less in height: Constructed from 16-gauge metal with hemmed edges, 0.375-inch (9.5-mm) square rod, damper regulator designed with 2-inch high base for mounting on externally insulated duct and end bearing.
 - a. Basis of design:
 - (1) Regulator: Young Regulator Co. Model No. 443B-3/8
 - (2) End bearing: Young Regulator Co. Model No.429 FD.
- 3. Provide locking regulators.

C. Counterbalanced backdraft dampers:

1. Constructed with galvanized steel channel frame. Blades shall be 16-gauge minimum galvanized-steel with neoprene blade seals and neoprene jamb seals, maximum width 7 inches (178 mm), mounted on a steel shaft with ball bearings. Field adjustable counterbalance. Frame shall have a rust-inhibitive coating applied at the factory.
2. Basis of design: Ruskin Type CBS7.

D. Counterbalanced backdraft dampers for use in fan discharge:

1. Constructed with galvanized steel channel frame. Blades shall be 18-gauge minimum galvanized-steel airfoil type, with EPDM blade seals and neoprene jamb seals, maximum width 7 inches (178 mm), mounted on a steel shaft with ball bearings. Individual blades shall be connected together to work in unison. Field adjustable counterbalance. Frame shall have a rust-inhibitive coating applied at the factory.
2. Basis of design: Ruskin Type CBS8.

2.8 DUCT CLAMPS

- A. Duct clamps for flexible duct and flexible fabric connections: Positive locking drawbands able to conform to any shape. Fabricate from a single piece of stainless steel, with hex screw and worm gear.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Duct accessories shall be mounted or installed properly in accordance with the manufacturer's instructions and as indicated on the drawings.

3.2 INSTALLING FLEXIBLE CONNECTIONS

- A. Flexible connections: Install using flexible joint fabric where duct connects to motor-driven equipment, and in other locations shown on drawings. Securely clamp flexible connection to duct and collar with duct clamps, providing 1 inch (25 mm) slack. Stitch seams with fiberglass thread.

1. Flexible connections are not required where duct connects to air-handling equipment with internally isolated fans.

3.3 INSTALLING SCREENS

- A. Install bird screens in outdoor air and exhaust air connections.
- B. Install bird screen at open ended duct terminations and where indicated on mechanical drawings.

3.4 INSTALLING MANUFACTURED UNITS

- A. Install necessary devices to balance the air flow to produce air quantities at outlets as indicated on the drawings.
- B. Install turning vanes in 90-degree square elbows.
- C. Install spin-in fittings as indicated on the drawings. Mechanically fasten to duct main with screws or rivets.

3.5 INSTALLING DUCT ACCESS DOORS

- A. Install duct access doors in ductwork for access to control devices, and any other devices, equipment, or components requiring maintenance, service, or adjustment and located inside ducts or adjacent equipment.

3.6 INSTALLING DAMPERS

- A. Install dampers at locations indicated on drawings and where required to properly balance the systems and to deliver the air quantities indicated. Each damper shall have substantial operators of proper size with locking facilities.

END OF SECTION

SECTION 23 3346

FLEXIBLE DUCTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Insulated flexible ducts.

1.2 REFERENCES

- A. UL 181: Factory-Made Air Ducts and Air Connectors.
- B. NFPA 90A: Standard for the Installation of Air-Conditioning and Ventilating Systems

1.3 SUBMITTALS

- A. Product data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURED SPECIAL FLEXIBLE DUCTS AND FITTINGS

- A. Insulated flexible duct: UL 181, Class 1, factory pre-insulated, complying with NFPA 90A
 - 1. Core: Non-metallic airtight polyester supported by galvanized steel wire helix.
 - 2. Insulation: Fiberglass, R-6 (RSI-1.06) minimum.
 - 3. Vapor barrier: Aluminized and reinforced.
 - 4. Pressure Rating: 10 inches water gauge (2,500 Pa) positive and 1 inch water gauge (250 Pa) negative up to an 18 inch (457 mm) diameter.
 - 5. Maximum Air Velocity: 4,000 feet per minute (20 meters per second)
 - 6. Temperature Range: Minus 20 to plus 210 degrees F (Minus 29 to plus 99 degrees C).
- B. Flexible duct connectors:
 - 1. Clamps: Stainless-steel bands with cadmium-plated hex screw to tighten band with a worm-gear action, to suit duct size.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Before fabricating ductwork, make field measurements and coordinate layout of ductwork shown on the drawings with building components and work of other trades. Resolve conflicts and obtain written approval for deviations before fabrication.
- B. Generally, it is intended that all horizontal ductwork be a minimum of 10 inches (255 mm) above suspended ceiling (where applicable) to allow for removal of ceiling panels and ceiling-mounted light fixtures and devices.
- C. Provide insulated flexible duct where shown on drawings:
 - 1. Install ducts fully extended.
 - 2. Do not bend ducts across sharp corners.

3. Lay out bends and turns with the longest practicable radius.
 4. Bends of flexible ducting shall not have an inside radius less than one duct diameter.
 5. Avoid contact with metal fixtures, water lines, pipes, or conduits.
 6. Install flexible ducts in a direct line, without twists, or turns.
 7. Lengths shall not exceed 10 feet (3,000 mm).
- D. Connections: Coat at least 3 inches inside the end of the flexible duct core with duct sealant, install over the rigid duct, and secure with a duct clamp. After replacing the insulation and vapor barrier, secure with another duct clamp.
- E. Supporting Flexible Ducts:
1. Suspend flexible ducts with bands 1-1/2 inches (38 mm) wide or wider and spaced a maximum of 48 inches (1,200 mm) apart. Maximum centerline sag between supports shall not exceed 1/2 inch (13 mm) per 12 inches (300 mm).
 2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
 3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
 4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches (1,800 mm) on center.

END OF SECTION

SECTION 23 3400

HVAC FANS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Centrifugal fans.
- B. Exhaust fans.
- C. Accessories.

1.2 RELATED SECTIONS

- A. Vibration control supports: Section 23 0548.
- B. Motors: Section 23 0513.

1.3 SUBMITTALS

- A. Shop drawings detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Reports of specified factory tests.
- B. Product data: Include rated capacities of each unit, weights (shipping, installed, and operating), furnished specialties, accessories, and the following:
 - 1. Certified fan performance curves with system operating conditions indicated. Include static pressure, brake horsepower, and static efficiency plotted against air volume.
 - 2. Certified fan sound power ratings.
 - 3. Motor ratings and electrical characteristics, and motor and electrical accessories.
 - 4. Material gauges and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
- C. Wiring diagrams detailing power and control wiring and differentiating clearly between manufacturer-installed and field-installed wiring.
- D. Maintenance data as required in Division 01 and Section 23 0101.
- E. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.

1.4 QUALITY ASSURANCE

- A. Fans shall be tested and rated in accordance with the applicable AMCA Standard Test Code and Certified Rating Program and bear AMCA Certified Air Rating Seal.
- B. Fan selections shall be made to the right of the peak static pressure point, but not on any "flat" portion of the fan curve. Generally, fan selection shall be in the 50 percent to 80 percent range of wide open volume.

- C. HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.
- D. UL label and local testing (if required): Section 23 0500, Common Work Results for HVAC.

1.5 COORDINATION

- A. Coordinate the installation of roof curbs, supports, and roof penetrations. Fan installation shall not reduce weathertightness of roof nor violate roof warranty.
- B. Coordinate colors selected for roof-mounted fans with colors of other roof-mounted equipment.

1.6 EXTRA MATERIALS

- A. Provide adjustments in drives and sheaves and belts as required at time of system balancing to obtain the airflow and static pressure indicated on drawings.

PART 2 - PRODUCTS

2.1 FANS, GENERAL

- A. Fan size, capacity, class, arrangement, accessories and discharge shall be as scheduled on the drawings.
- B. Motors shall meet the requirements of Section 23 0513, Common Motor Requirements for HVAC Equipment, including power factor and efficiency.
- C. Belt drives and exposed rotating shafts shall be provided with guards meeting OSHA and MOSHA requirements.
- D. Fans shall have self-aligning, ball-type bearings designed for thrust load, and grease fittings shall be accessible for relubrication. Fans shall be statically and dynamically balanced.
- E. Motors for belt-driven units shall have adjustable variably pitched cast iron sheaves to allow a 10 percent increase or reduction in speed. Belts shall be sized for minimum 150 percent brake horsepower (bhp).
 - 1. Include one change in drive sheave for each unit if necessary to obtain correct air quantities at time of testing, adjusting, and balancing.

2.2 CENTRIFUGAL FANS

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified Twin City product, or comparable product by one of the following:
 - 1. Aerovent, a Twin City Fan Company
 - 2. Briedert Air Products
 - 3. Carrier Corp.
 - 4. Clarage Fan Co.
 - 5. Greenheck Fans
 - 6. Howden Buffalo Inc.
 - 7. Loren Cook Co.
 - 8. New York Blower Co.
 - 9. Peerless Blowers
 - 10. Penn Barry

11. Trane Co.
12. Twin City Fans and Blowers
13. Or approved equal.

- B. Housing: Steel, with seams continuously welded, with angle or channel side support members and motor access plates. Discharge outlet shall conform to AMCA recommended standards. Inlet shall have spun cones to provide streamlined airflow into fan wheel. Fan shall have hinged access door in scroll extended for one-inch-thick insulation.
1. Fans installed outdoors: Weatherproof, including cover for motor and drive.
 2. Base-mounted centrifugal fans 30-inch wheel diameter and larger shall have horizontal split housings.
- C. Bearings shall be heavy-duty, self-aligning, ball type with a design average life of 200,000 hours or more based on the optimum speed range of the fan's AMCA class and furnished with grease fittings, extended to be accessible from outside of ducts. Bearings shall be rigidly supported on structural supports connected to the structural base member of the fan. Fan shafts shall be of cold-drawn or forged steel, turned, ground, polished and machined to close tolerance, and keyed to fan wheel.
- D. Motor, unless scheduled otherwise, shall be 1750 maximum rpm and suitable for voltage noted on drawings. Two-speed motor, where scheduled, shall be dual winding type. Motors shall have adjustable bases.
- E. Fans mounted without duct connections shall be provided with inlet screens.
- F. Finish:
1. Complete fan assemblies shall have two coats of enamel paint.
 2. Fans mounted on the roof shall be painted to match other roof-mounted equipment.

2.3 EXHAUST FANS

- A. Basis-of-design product: Subject to compliance with requirements, provide the specified Acme Engineering and Manufacturing product, or comparable product by one of the following:
1. Aerovent, a Twin City Fan Company
 2. Acme Engineering and Manufacturing
 3. Greenheck Fans.
 4. Jenco Fan.
 5. Loren Cook, Inc.
 6. Penn Barry.
 7. Twin City Fans and Blowers.
 8. Or approved equal.
- B. In-line fan (square): Fan housings, fan wheel and other parts used in the fabrication of the units shall be aluminum or steel of design and gauge standard with the manufacturer. Lubricating tubes shall be provided from the shaft bearings to the housing. Units shall have support brackets for mountings as shown on drawings. Impeller shall be airfoil blades welded to the hub and have non-overloading characteristics. Wheel shall be statically and dynamically balanced. Wheels shall be backward-inclined, non-overloading, with aluminum blades. Inlet cones shall be provided. Directly driven units shall have motors out of air stream and shall be prewired to an external twist-lock receptacle.

2.4 ACCESSORIES

- A. Bird screens: Specified in Section 23 3300, Duct Accessories.
- B. A disconnecting switch without overload protection shall be included under the weather hood of roof-mounted units, completely factory-wired to motor and mounted independently of the motor. Motors for directly driven units shall be provided with solid-state variable speed control connected downstream on the load side of the disconnecting switch, unless otherwise indicated on the drawings.
- C. Provide each unit with self-operating aluminum backdraft damper and frame unless indicated otherwise on the drawings. Damper blades shall operate in unison and shall be counterbalanced or otherwise provided with facilities to positively open under fan suction and to close tight when subject to backdraft.
- D. Identification: Each fan shall be identified with a fan number no less than 0.5 inch high, as shown in the fan schedule, on an aluminum strip riveted to hood of roof fans and on the motor side of frame for wall fans.

PART 3 - EXECUTION

3.1 INSTALLATION, EXHAUST FANS

- A. Fans shall be installed in compliance with the manufacturer's recommendations. Ventilating and ceiling exhaust fans shall be supported from the building structure, not attached to the ceiling suspension members or discharge grille system.
- B. Coordinate with air balancing and provide adjustments, sheaves, and belts as required in Part 1 above to obtain the airflow and static pressure indicated on the drawings.

3.2 OPERATING INSTRUCTIONS

- A. As specified in Section 23 0500, provide operating instructions.
- B. Provide at least 4 hours of additional instruction time for the equipment specified in this section, consisting of 1 period of 4 consecutive hours.

END OF SECTION

SECTION 23 3713

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Ceiling- and wall-mounted diffusers, registers, and grilles.

1.2 RELATED SECTIONS

- A. Balancing: Section 23 0593.

1.3 REFERENCES

- A. NFPA 90A: Standard for the Installation of Air-Conditioning and Ventilating Systems.

1.4 SUBMITTALS

- A. Product data: Each type of diffuser, register and damper, and grille, including frames and accessories, and performance data.
- B. Shop drawings:
 - 1. Schedule, including size, location, function, and finish of each diffuser, register, and grille.
 - 2. For each air control device, provide information required to balance the system. Include the factor for each size and type of device for converting velocity to volume.
 - a. Include this information in Operating and Maintenance Manuals.
- C. Samples: Manufacturer's complete line of color chips for anodized aluminum linear grilles and diffusers.

PART 2 - PRODUCTS

2.1 AVAILABLE MANUFACTURERS

- A. Grilles, registers and diffusers:
 - 1. Hart and Cooley Inc.
 - 2. Krueger.
 - 3. Metalaire.
 - 4. Nailor Industries, Inc.
 - 5. Price Company.
 - 6. Titus Products.
 - 7. Or approved equal.

2.2 DIFFUSERS, REGISTERS, AND GRILLES

- A. Devices of one of the named manufacturers, with performance data, characteristics, features, and accessories of the model or type specified or indicated on the drawings. Model numbers specified below are Krueger except as noted otherwise.

- B. See architectural drawings for type of walls and ceilings where diffusers, grilles, and registers are required. Coordinate margin and frame of each device with the substrate in which it will be installed. Where devices are installed in suspended ceilings, assure that they will fit correctly in the type of suspension supports shown or specified.
- C. Materials and finish:
 - 1. Construction:
 - a. Steel where mounted in ceilings.
 - b. Either aluminum or steel where mounted in walls near ceiling.
 - c. Heavy-duty steel where mounted in walls near floor.
 - d. Welded or mechanically fastened cores in diffusers located in gymnasium.
 - 2. Aluminum devices shall be all aluminum construction, including dampers, where specifications call for aluminum or stainless-steel ductwork.
 - 3. Finish: Manufacturer's standard white enamel, suitable for final finish or for field painting, unless indicated otherwise.
- D. Where narrow margin grilles and registers are specified or indicated on the drawings, they shall be provided with mounting frames except where mounted on ductwork.

2.3 SUPPLY DIFFUSERS

- A. Throw length is based on performance data of the scheduled or specified manufacturer and model. Select units of other manufacturers whose performance data meet the required conditions. Throw direction of square and rectangular ceiling diffusers shall be four-way unless otherwise indicated on the drawings.
- B. Square and rectangular ceiling diffusers: Square, rectangular, or round neck and removable core. Each unit shall have a straightening grid. The grids shall be set at right angles to one another. Basis of design: Krueger Series SH.
 - 1. Frame Style 23 (panel diffuser): Diffusers mounted in nominal 24 by 24-inch (600 by 600-mm) or 24 by 48-inch (600 by 1200-mm) flat steel panels as indicated on the drawings, to lay into suspended ceiling grid of acoustical ceilings.
 - 2. Frame Style 22 (surface mount): Diffuser with flat frame to mount at underside of plaster or gypsum wallboard ceilings.

2.4 SUPPLY GRILLES AND REGISTERS

- A. For registers, provide opposed-blade dampers with linkage and adjustment through grille face with a screwdriver or allen wrench.
- B. Wall-mounted near ceiling:
 - 1. Grilles and registers, double deflection with horizontal face bars, minimum 1.25-inch (32-mm) overlap margin.
 - 2. Basis of design:
 - a. Grilles: Krueger 5880H (aluminum).

2.5 RETURN AND EXHAUST GRILLES AND REGISTERS

- A. For registers, provide opposed-blade dampers with linkage and adjustment through grille face with a screwdriver or allen wrench.
- B. Ceiling-mounted and wall-mounted near ceiling: Grilles and Registers, fixed horizontal face bars set at 35 to 45 degrees deflection, minimum 1.25-inch (32-mm) margin.
 - 1. Basis of design:
 - a. Grilles: Krueger S-80H (steel); S-580H (aluminum).

PART 3 - EXECUTION

3.1 INSTALLING GRILLES, REGISTERS AND DIFFUSERS

- A. Securely attach grilles, registers, and diffusers in place. Do not install the grilles and registers until duct interiors have been painted as specified in Section 23 0500, Common Work Results for HVAC.
- B. Install all air control devices complete with the accessories specified, securely attached in position. Make operating devices accessible.
- C. Adjust diffuser straightening grids to provide uniform air distribution above diffuser face.
- D. Adjust supply register deflectors to provide uniform air distribution to the areas served.

END OF SECTION

SECTION 23 4100

PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Filters for temporary service during construction, including changes required to meet the requirements of Indoor Air Quality Management in Division 01.
- B. Provide 2 sets of filters for every item of equipment requiring filters, as follows:
 - 1. One set of filters for regular service, installed before air balancing.
 - 2. Remaining set of filters for regular service, provided as extra materials for future use.

1.2 RELATED SECTIONS

- A. Air-source heat pump units: Section 23 8143.
- B. Ductless split-system units: Section 23 8127.

1.3 REFERENCES

- A. ASHRAE 52.1: Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices used in General Ventilation for Removing Particulate Matter.
- B. ASHRAE 52.2: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
- C. ARI 850: Commercial and Industrial Air Filter Equipment.

1.4 DEFINITIONS

- A. MERV: Minimum Efficiency Reporting Value as determined by ASHRAE 52.2.
- B. Temporary service: Operation of equipment during the construction period, before air balancing.
- C. Regular Service: Operation of equipment during air balancing and in normal use during occupancy.

1.5 SUBMITTALS

- A. Product data: For filters, include filter ratings, rated flow capacity, and fire classification.
- B. Shop drawings: Illustrate assemblies and attachments.
- C. Closeout submittals: As required for Operating and Maintenance Manuals in Division 01 and Section 23 0101, provide a schedule of locations of filters, identifying equipment and filter types and sizes, including prefilters and final filters.

1.6 QUALITY ASSURANCE

- A. Provide all filters for regular service from a single manufacturer.

- B. Test filters by methods described in ASHRAE 52.1 and ASHRAE 52.2.
- C. Comply with ARI 850.

1.7 EXTRA MATERIALS

- A. Disposable and throwaway filters: For each filter included for regular service, provide 1 extra filter. Identify each filter with its name and intended location and use.
- B. Provide filters and media in protective packaging, with identifying labels or markings.
- C. Except as otherwise required in Division 01, deliver to location designated by the Government, and shelve or stack as directed.

PART 2 - PRODUCTS

2.1 AVAILABLE MANUFACTURERS

- A. Basis-of-design products: Subject to compliance with requirements, provide specified or scheduled products, or comparable product by one of the following:
 - 1. Filters:
 - a. AAF International.
 - b. Airguard; Clarcor Air Filtration Products
 - c. Camfil Farr
 - d. Flanders Filters, Inc.
 - e. Or approved equal.
 - 2. Filter Gauges:
 - a. Dwyer Instruments, Inc.
 - b. H.O. Trerice Co.
 - c. Miljoco Corporation
 - d. Weksler Instruments
 - e. Or approved equal.

2.2 FILTERS, GENERAL

- A. Coordinate with approved manufacturers of the various approved air handling units and equipment for filter size and thickness required.
- B. Thickness: Generally, large air handling units shall have filters 2 inches and thicker. Smaller units such as fan-coil units may be limited to filters 2 inches thick.
- C. Filter face areas: As scheduled, or equivalent to one square foot for each 300 cfm.

2.3 THROWAWAY FILTERS

- A. FS F-F-310, Type I throwaway frame and media, Grade B high dust holding capacity, of size and thickness to fit units.

2.4 DISPOSABLE FILTERS, MERV 8

- A. Class 2, thickness 1 and 2 inches, and size required for each location, disposable.

- B. Rating in accordance with ASHRAE 52.1:
 - 1. Average efficiency: 25 to 30 percent.
 - 2. Average arrestance: 90 to 92 percent.
- C. Rating in accordance with ASHRAE 52.2: MERV 8.
- D. UL 900: Class 2.
- E. Medium: Non-woven, reinforced cotton and synthetic fabric, pleated.
- F. Medium support grid: Welded wire with an effective open area not less than 96 percent, bonded to medium.
 - 1. Performance: Medium shall not oscillate nor pull away from support grid.
 - 2. Design: Tapered radial pleats, supporting medium both vertically and horizontally.
- G. Enclosing frame: High-wet-strength beverage board, with diagonal supports bonded to media pleats. Filter pack continuously bonded to inside of frame so that no air leaks around edges.
- H. Basis of design: Camfil Farr "Aeropleat IV."

2.5 DISPOSABLE FILTERS, MERV 13

- A. High-efficiency, mini-pleated, 4-inch deep, disposable type. Each filter assembly shall consist of a high-efficiency filter, medium retainer and holding frame.
- B. Medium: Microfine glass media in a close-pleat design bonded into a beverage board holding frame.
- C. Rating in accordance with ASHRAE 52.1: Average efficiency 80-85 percent, and average arrestance not less than 98 percent.
- D. Rating in accordance with ASHRAE 52.2: MERV 13.
- E. The initial resistance to airflow shall not exceed 0.5 inch wg at 500 fpm.
- F. UL 900: Class 2.
- G. Basis of design: Camfil (Farr) Opti-Pac.

2.6 FILTER GAUGE

- A. Gauge:
 - 1. Range zero to 3 inches wg, with divisions of 0.10 inch.
 - 2. Basis of design: Dwyer "Magnehelic", Series 2000
- B. Accessory package: To adapt the magnehelic gauge for use as a filter gauge. Package includes aluminum surface-mounting bracket with screws, two 5-foot lengths of 0.25-inch aluminum tubing, two static pressure tips, and two molded plastic vent valves, with integral compression fittings on both tips and valves.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Before startup of each item of equipment requiring a filter, install filters for temporary service.
 - 1. Generally, provide throwaway filters for temporary service.
 - 2. On equipment with prefilter and final filter, provide only the specified prefilter for temporary service.
- B. Immediately prior to air balancing, remove temporary filters and install filters required for regular service.

3.2 INSTALLING FILTER GAUGE

- A. Mount across filter section in accordance with manufacturer's instructions.

END OF SECTION

SECTION 23 8127

DUCTLESS SPLIT-SYSTEM UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Ductless split system with interior and exterior units and refrigerant piping.
- B. Heat pump units.

1.2 RELATED SECTIONS

- A. Motors: Section 23 0513.
- B. Piping: Section 23 2300.
- C. Refrigeration service and compressor warranty: Section 23 0100.
- D. Filters: Section 23 4100.

1.3 REFERENCES

- A. ASHRAE 15: Safety Code for Mechanical Refrigeration.
- B. ASHRAE 90.1: Energy Efficient Design of New Buildings Except Low-rise Residential Buildings.

1.4 PERFORMANCE REQUIREMENTS

- A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under the article "Acceptable Manufacturers" below, ascertain that it will:
 - 1. Perform to the scheduled and specified capacities.
 - 2. Make no additional demands on other systems such as domestic, heating, and chilled water, or electricity.
 - 3. Meet or exceed all specified requirements.
 - 4. Electrical power connections for the basis-of-design unit require the indoor unit to be wired through the outdoor unit. Other manufacturers may require separate power connections, which the contractor shall provide as required.

1.5 SUBMITTALS

- A. Shop drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring diagrams: For power, signal, and control systems, differentiating between factory- and field-installed wiring.
- B. Product data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each model.

1. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
2. Submit precharged tubing description.

C. Samples: Color chips, showing manufacturer's complete line of finishes.

1.6 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 23 0500, Common Work Results for HVAC.
- B. Fabricate and label refrigeration components to comply with ASHRAE 15.
- C. Energy efficiency ratio and coefficient of performance: Equal to or greater than prescribed by ASHRAE 90.1.

1.7 SPECIAL WARRANTY

- A. Besides general project warranty, provide manufacturer's seven-year extended warranty for replacing compressors, for each system, executed to the Government.

PART 2 - PRODUCTS

2.1 AVAILABLE MANUFACTURERS

- A. Basis-of-design product: Subject to compliance with requirements, provide the scheduled Mitsubishi Electric Corporation P Series unit, or comparable product by one of the following:
 1. Daikin
 2. Enviromaster International (EMI)
 3. Mitsubishi Electric Corporation
 4. Panasonic Air Conditioning Group
 5. Trane
 6. Or approved equal.

2.2 MATERIALS

- A. Refrigerant: HFC 410a.
- B. Refrigerant pipe: Precharged Type L soft drawn, preinsulated seamless copper tubing, ASTM B 280. Length: As short as possible.

2.3 UNITS, GENERAL

- A. Each unit shall be provided with factory-installed means of disconnect in compliance with NEC (NFPA 70) and local codes. In the event a factory-installed disconnect is not available, provide an approved means of disconnect for field mounting.
- B. Heat pump units: Include reversing valves and defrost controls. When heat is called for, the reversing valve reverses the refrigerant flow, the interior coil operates as a condenser, heat is circulated into the room, and the outdoor coil operates as an evaporator.

2.4 INTERIOR UNIT

- A. Frames: Steel angles or aluminum extrusions, welded construction.

B. Panels:

1. Insulated with 0.5-inch (13-mm) thick, 2 lbs per cubic foot (32 kg per cubic meter) density glass fiber insulation, with an R value no less than 15.
2. Fasteners: Concealed, captive, easily operated for access without tools.
3. Exterior finish: Manufacturer's standard baked enamel.

C. Grilles: Each one-piece construction, aluminum, brushed finish, with foam gasket providing airtight seal between grille and cabinet. Supply grille adjustable in three directions. Return air grille hinged for access to filter.

D. Drain pan: Insulated steel or plastic, with connections to exterior of cabinet.

1. Slope to drain in two directions, minimum 0.25 inch in 1 foot, to 0.75-inch drain connection.
2. Provide access for cleaning.

E. Cooling coil: Aluminum fins extruded on to copper tubing with quick connections to precharged tubing. Pressure tested at 1.5 times working pressure. Provide expansion device.

F. Fan: Centrifugal type with direct-connected controlled-speed motor mounted on vibration isolators.

G. Filter: Throwaway type.

2.5 EXTERIOR UNIT

A. Unit shall be factory-assembled and -tested, of capacity and current characteristics indicated on the drawings. Unit shall be packaged type. Cabinet: weatherproof construction, steel, with baked enamel finish.

B. Refrigeration circuit: Completely pre-piped, equipped with refrigerant; access valves in suction and liquid lines; filter dryer, sight glass, and pressure fittings for charging and evacuation.

C. Compressors: Welded shell; reciprocating hermetic, rotary screw or scroll type; high efficiency.

D. Condenser coil: Constructed of copper tube and aluminum fins, factory leak-tested at 1.5 times working pressure, dehydrated, and provided with full charge of refrigerant. Provide subcooler and accumulator.

1. Low ambient control: Provide head pressure control and accessories required to operate at temperatures down to 0 degrees F (minus 18 degrees C).

E. Fans: Propeller, direct drive, dynamically balanced, speed-controlled motor.

2.6 CONTROLS

A. Wall-mounted hard-wired controllers shall incorporate the following features:

1. Operation mode setting (Heat, Auto, Cool)
2. Temperature setting: The LCD indicator displays the set temperature in units of 2 degrees F.
3. Room temperature (intake air) display
4. 24-hour on/off timer: Operation can be set to start or stop after a specified time in 1-hour increments from 1 to 24. The remaining time is indicated on the LCD display.
5. Fan speed indicator: Displays the fan speed setting (high or low).

6. Vane control: The angle of the air outlet vanes can be adjusted to one of four positions by pressing the air discharge Up/Down button.
7. Auto air swing vanes: The air outlet vanes swing up and down for uniform air distribution.
8. Self-diagnostic display: When unit stops, the display indicates where the trouble is located.
9. Memory feature for storing instructions

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Assemble and set each unit in place in accordance with the manufacturer's instructions, plumb and level, firmly anchored, maintaining manufacturer's recommended clearances, tight to adjoining surfaces.
- B. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.
- C. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.
- D. Connect piping as shown on the drawings and in accordance with manufacturer's instructions.
- E. In a finished space, all piping, wiring, and conduit shall be behind finished surfaces.
- F. Test each drain pan and ensure that installed slope is as specified and pan drains completely.
- G. Filters:
 1. Provide throwaway filter before energizing the unit fan.
 2. Before air balancing, remove throwaway filter and install disposable filter.
- H. Install accessories required for low ambient operation.

3.2 SYSTEM CONTROLS INSTALLATION

- A. Provide the entire system with required controls, including wall-mounted controller, designed and installed by the equipment manufacturer to provide a complete working system.
- B. Provide wiring in compliance with the requirements of the Division 23 Section "Control System Wiring."

3.3 OPERATING INSTRUCTIONS

- A. As specified in Section 23 0500, provide operating instructions.

END OF SECTION

SECTION 23 8143

AIR-SOURCE HEAT PUMP UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Split-system heat pump units.

1.2 RELATED SECTIONS

- A. Refrigeration equipment startup and maintenance: Section 23 0100.
- B. Refrigeration piping: Section 23 2300.
- C. Motors: Section 23 0513.
- D. Filters: Section 23 4100.

1.3 PERFORMANCE REQUIREMENTS

- A. Design of the HVAC system, including associated work of other design disciplines and trades, is based on scheduled and specified equipment. If a different item of equipment should be proposed, as permitted under "Available Manufacturers," below, ascertain that it will:
 - 1. Perform to the scheduled and specified capacities.
 - 2. Make no additional demands on other systems such as domestic, heating, and chilled water, or electricity.
 - 3. Meet or exceed all specified requirements.

1.4 SUBMITTALS

- A. Shop drawings: Heat pump units
- B. Product data: Heat pump units and dampers, including leak test data.
- C. Unit shown on drawings is based on the dimensions of the design basis unit specified in Part 2 below. If another acceptable manufacturer's unit should be proposed, ascertain that it will fit in the available space.
 - 1. Include, with shop drawings of the unit, scale drawings similar to the contract drawings, including plans, elevations, sections, and diagrams, showing any changes in wiring, arrangement, or access necessary to accommodate the proposed unit.
 - 2. Include shop drawings and product data sufficient to show conformance to the article "Performance Requirements" above.
- D. Shop drawings shall show complete dimensions of complete assembled unit with accessories, including dimensions and configuration as required to coordinate with framing and bracing roof structure and deck.
 - 1. Include design of refrigeration piping prepared by manufacturer of the refrigeration compressor.
 - 2. Wiring diagrams: Prepared for this project.

- E. Submit product data which verifies compliance with ASHRAE 90.1, or provide certified performance ratings by a qualified independent testing agency.
- F. Certifications: Availability of replacement parts and compressors as required in Part 2 below.

1.5 QUALITY ASSURANCE

- A. UL label and local testing (if required): As specified in Section 23 0500, Common Work Results for HVAC.
- B. Regulatory requirements:
 - 1. ICC: HVAC equipment shall meet the energy performance requirements of ASHRAE 90.1.
 - 2. COMAR 14.26.03: Packaged equipment with over 20 tons of cooling capacity shall meet Tier 2 requirements for minimum efficiencies for unitary commercial air conditioners or heat pump units of the Consortium for Energy Efficiency (CEE), in effect on 1 January 2002.
 - 3. EPA: Refrigerant: HFC-410A.

PART 2 - PRODUCTS

2.1 AVAILABLE MANUFACTURERS

- A. Basis-of-design products: Subject to compliance with requirements, provide specified or scheduled Trane products, or comparable product by one of the following:
 - 1. Valent.
 - 2. Aeon
 - 3. Or approved equal.

2.2 HEAT PUMP SPLIT SYSTEM

- A. System shall be split-type heat pump system consisting of an outdoor condensing unit and indoor fan with cooling coil and electric reheat coils (air handling unit). All units and sections shall be of one manufacturer.
- B. System shall be approved by manufacturer for operation in cooling between 100 and minus 10 degrees F, outdoors.
- C. Outdoor sound rating number in ARI Directory shall not exceed 22.
- D. Capacity and electric current characteristics of system: Indicated on the drawings.
- E. Outdoor equipment shall be listed by Underwriter's Laboratories as suitable for outdoor installation. Each unit shall meet the applicable ARI standards.
- F. Replacement parts and compressors shall be available from a warehouse located in the Baltimore-Washington-D.C. metropolitan area.
- G. Heat pumps shall have factory-installed switchover valves and check valves. Heat pump thermostat shall have built-in emergency heat switch and heating control shall be outdoor temperature compensated. Heat pump control system shall prevent use of supplementary resistance heat when outdoor temperature rises above 45 degrees F. Heat pump defrost cycle shall operate only when outdoor coil has excessive pressure drop and defrost control shall also energize supplementary resistance heaters.

- H. Outdoor condensing unit: Galvanized steel weatherproof unit with weather resistant finish, containing hermetic or semihermetic compressors, condensers, condenser fans, service valves, internal pressure relief valves, liquid line filter-drier, compressor overload, safety and operation controls. Unit shall be completely factory assembled and wired, and have access panels for service and maintenance.
- I. Air-handling unit: Steel construction, fully insulated, including fan and fan motor. Blower system may be multispeed directly driven or belt-driven, provided it meets airflow requirements indicated on the drawings. Air handler shall be UL listed and shall meet requirements of ARI 210/240. Unit shall have removable access panels properly located for service and maintenance.
- J. Coils shall be constructed of aluminum plate fins mechanically bonded to non-ferrous tubing with all joints brazed.
- K. Motors shall comply with the requirements of Section 23 0513.
- L. Unit shall be provided with factory installed means of disconnect in compliance with NEC and local codes. In the event a factory installed disconnect is not available as an option, an approved means of disconnect shall be provided for field mounting.
- M. Electric resistance heaters shall fit within the air handler cabinet or shall be duct type as indicated on the drawings. Electric heater shall be UL listed for use with air handler.
- N. All the necessary outdoor thermostat, time delay relays, air sensing control for defrost cycle, low ambient controls, transformers, and necessary appurtenances shall be provided factory-wired to provide a completely integrated system.
- O. Provide factory precharged and preinsulated refrigerant lines of the length required.
- P. Provide filter rack with two inch deep disposable MERV 8 filter and 4 inch deep MERV 13 filter, maximum 300 cfm per square foot. Provide filters as specified in Section 23 4100.

2.3 OUTDOOR AIR DAMPER

A. Damper:

- 1. Construction: Extruded aluminum frames and blades.
- 2. Blades: Maximum width 6 inches. Seals mechanically fastened extruded-bulb type, neoprene or vinyl. Seals fastened to blade with adhesive are not acceptable.
- 3. Performance: Maximum total leakage 0.5 percent when subjected to static pressure of 2 inches water gauge.
- 4. Basis of design: Arrow United Industries "Pin-lock" No. OBDPL-507, Johnson Controls **VD-1250**, or equal by Honeywell, Inc.

B. Operator:

- 1. Two-position spring-return type, 240 volt, complete with mounting brackets and coupler to damper.
- 2. Basis of design: Honeywell, Inc. Model M436A.

2.4 CONTROL SEQUENCE

- A. The following controls shall be provided by the unit manufacturer.

1. Room thermostat manual changeover, 24 volt heat/cool complete with fan "Auto-On" switch and system "Heat-Off-Cool."
 2. All outdoor thermostats for operation of heat pump and supplemental heaters during heating mode.
 3. Time delay relays in the control circuit to prevent all supplemental heaters from being energized at once.
 4. Air sensing control for defrost cycle.
 5. Low ambient operation control.
- B. The supplemental electric heaters shall be energized during the heat pump "Defrost" cycle.
- C. OA damper for system shall be furnished for duct mounting. Whenever the fan motor is deenergized, the OA damper shall close tight.
- D. Provide under this section:
1. Wiring for OA damper operator including a switch beside room thermostat to shut damper during "Unoccupied" operation. Plastic nameplate on switch shall read "OA Damper/Open/Closed."
- E. Occupied cycle system manually in "Heat" position:
1. Unit fan shall run continuously as set manually on room thermostat in "On" position.
 2. After start of unit fan the OA damper shall open to minimum position when damper switch is set in "Open" position.
 3. On a rise in room temperature, the electric heating coils shall be deenergized in steps. These steps are also controlled by outdoor thermostats and time delay relays in accordance with recommendations of the unit manufacturer.
 4. On a further rise, the compressor shall be deenergized in the heating mode.
 5. On a fall in room temperature, the cycle shall reverse.
- F. Occupied cycle system manually in "Cool" position:
1. Unit fan shall run continuously as set manually on room thermostat in "On" position.
 2. After start of unit fan the OA damper shall open to minimum position when damper switch is set in "Open" position.
 3. On a rise in temperature, the heat pump changeover valve shall be energized and the heat pump shall be energized in a cooling mode.
 4. On a fall in room temperature, the cycle shall be reversed.
- G. Unoccupied cycle:
1. Unit shall be controlled as manually set on room thermostat normally on the following settings:
 - a. System switch "Heat" position.
 - b. Fan switch in "Automatic" operation.
 - c. OA damper switch in "closed" position.
 2. Unit and fan will cycle to maintain the set point of the "Heat" thermostat.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Assemble and set the air-handling units in place as indicated.
- B. Connect piping and ductwork as shown on the drawings.
- C. Coordinate with air balancing to obtain the airflow and static pressure indicated on the drawings.

3.2 MANUFACTURER'S FIELD SERVICE

- A. Provide refrigeration equipment startup, and service during the correction period by a factory authorized agent as specified in Section 23 0100.

3.3 OPERATING INSTRUCTIONS

- A. As specified in Section 23 0500, provide operating instructions.
- B. Provide at least 8 hours of additional instruction time for the equipment specified in this section, consisting of 2 periods of 4 consecutive hours, during a period of not less than 60 days.

END OF SECTION