Midwestern State University

McCoy Engineering Hall
Wind Tunnel Build-out
Project Manual

Prepared by
CEI CAMPOS ENGINEERING, Inc.
Consulting Engineers
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Design Team
Joe Campos, P.E.
Mike McKee, P.E.
Tim Campbell
Justin Dubar
Carter Fraser

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Specifications Table of Contents

DIVISION 23

23 00 10 - GENERAL REQUIREMENTS FOR HVAC SYSTEMS
23 05 48 - VIBRATION CONTROLS FOR HVAC
23 09 23 - CONTROL DAMPERS
23 31 13 - METAL DUCTS
23 33 00 - AIR DUCT ACCESSORIES
SECTION 23 00 10

GENERAL REQUIREMENTS FOR HVAC SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General Requirements for Mechanical Work are intended to be complementary to the General Requirements of the Construction Contract.

B. Work Included: Provide complete mechanical systems where shown on the drawings, as specified herein, and as needed for a complete and proper installation including, but not necessarily limited to the following summary of work:

1. Provide complete ductwork fabrication and installation with all required hangers, supports, and vibration isolation for the existing wind tunnel.
2. Ductwork shall be 10 gauge Type 304 stainless steel with satin finish (No. 2D). Refer to Specification 233113 Metal Ducts.
3. Provide gooseneck with removable birdscreen, flashing, and counter-flashing.
4. Provide two-position motorized dampers to enable wind tunnel to switch from a closed to an open loop. Refer to Sequence of Operations.
5. Provide access panels as shown on the drawings.
6. Provide drain ports at the bottom of ductwork elbows.
7. Other items and services required to complete the systems.

C. Deductive Alternate:
1. Provide pricing for 10 gage mill phosphatized finish G60 galvanized sheet metal in lieu of stainless steel.

D. Alternate:
1. Provide pricing for 2D satin finish on sheet metal ductwork noted in Deductive Alternate.

1.2 QUALITY ASSURANCE AND APPLICABLE STANDARDS

A. Use adequate numbers of skilled workers that are thoroughly trained and experienced in the necessary crafts and are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

B. Without additional cost to the Architect/Engineer/Owner, provide such other labor and materials as are required to complete the work of this Section in accordance with the requirements of governmental agencies having jurisdiction, regardless of whether such materials and associated labor are called for elsewhere in these Contract Documents.

C. Codes: Perform all work in accordance with the latest edition of the following codes:

1. State and city building, fire, plumbing, and mechanical codes.
2. National Electrical Code (NEC)
3. National Fire Protection Association (NFPA)
4. American with Disabilities Act (ADA)
5. Texas Accessibility Standards (TAS)
6. All authorities having jurisdiction.

D. Where conflicts occur between drawings, specifications, and code requirements, the most stringent requirement shall take precedence.

E. Standards: The specifications and standards of the following organizations are by reference made a part of these specifications. All work, unless otherwise indicated, shall comply with the requirements and recommendations wherever applicable:

1. American National Standards Institute (ANSI)
2. Air Conditioning and Refrigeration Institute (ARI)
3. American Gas Association (AGA)
5. American Society of Plumbing Engineers (ASPE)
6. American Society of Mechanical Engineers (ASME)
7. American Society of Refrigeration, Heating and Air Conditioning Engineers (ASHRAE)
8. Electrical Testing Laboratories (ETL)
10. National Electrical Manufacturer's Association (NEMA)
11. National Fire Protection Association (NFPA)
12. Sheet Metal and Air Conditioning National Association (SMACNA)
13. Underwriters Laboratories, Inc. (UL)

F. Electrical Characteristics for Equipment: Equipment of differing electrical characteristics may be furnished provided such equipment is proposed on the “Alternate Manufacturer Evaluation Form”, subsequently approved, and connecting electrical services, circuit breakers, and conduit sizes appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

G. When requested, provide the Owner’s Authorized Representative with manufacturer’s certificate that materials meet or exceed minimum requirements as specified.

1.3 REQUIREMENTS OF REGULATORY AGENCIES

A. The requirements and recommendations of the latest edition of the Occupational Safety and Health Administration (OSHA) Act are by reference made a part of these specifications. All work shall comply with the requirements and recommendations wherever applicable.
1.4 RELATED WORK SPECIFIED ELSEWHERE

A. All Other Sections of Divisions 21, 22, 23 and 26 (as applicable).

B. All other divisions of the contract documents. Refer to each division's specifications and drawings for all requirements

1.5 SUBMITTALS

A. Comply with pertinent provisions of Division 01.

B. Provide Specifications per Division 01 for all submitted alternate equipment.

Product Data: Submit the following:

1. Materials list of items proposed to be provided under Division 23.

2. Manufacturer's specifications and other data needed to prove compliance with the specified requirements. The term "Compliance" is understood to mean that the Contractor certifies that the submitted equipment will meet or exceed the contract document requirements. Items that do not clearly meet this definition should be identified and explained as required in the following paragraph.

3. Identify the difference between the specified item or function and the proposed. Explain with enough detail so that the Architect/Engineer/Owner can easily determine that the item complies with the functional intent. List any disadvantages or advantages of the proposed item versus the specified item. Submit technical data sheets and pictures and diagrams to support and clarify. Organize in a clear and concise format. All substitutions shall be approved in writing by Architect/Engineer. The Architect/Engineer's decision shall be final.

4. Allow a minimum of ten (10) working days for the review of submittals and each re-submittal.

5. Compliance with the Contract documents shall be the sole responsibility of the Contractor. Items on equipment that are not accepted by the Architect/Engineer in writing as an approved equal shall be replaced or revised to comply with the contract documents at the Contractor's expense.

6. Manufacturer's recommended installation procedures which, when reviewed by the Architect/Engineer, shall become the basis for accepting or rejecting actual installation procedures used on the work.

7. Sign the submittal as an indication of compliance with the contract documents. Any deviations from the contract documents shall be indicated on the submittal prior to signing. Any deviations not indicated shall be cause for rejection and removal of the non-complying equipment at the Contractor's expense.

C. Submittals required of materials and equipment under this section include the following:

1. Vibration Isolation and Sound Control Materials

   a. Submit shop drawings showing the structural design and details of custom-fabricated work not covered by manufacturer's submitted data.
b. Submit shop drawings indicating the scope of vibration isolation work, locations of units and flexible connections. Include support isolation points for all ductwork and equipment.

c. Include schedule of isolation units, showing size or manufacturer's part number, the weight supported and resulting deflection of each unit.

3. Air Handling

a. Provide clearly marked-up manufacturer's data showing compliance with scheduled values and specifications for:

1) Filters.

2) Intake/relief hoods.

4. Air Distribution Materials

a. Provide clearly marked-up manufacturer's data showing compliance with scheduled values and specifications for:

1) Control dampers.

2) 1/4" scale ductwork shop drawings for all systems showing equipment locations, detailed data such as bottom of duct elevations, airstream sizes, all duct accessories, and duct construction details showing compliance with SMACNA requirements for the specified duct pressure of each system.

5. Controls and Instrumentation

a. Provide detailed shop drawings showing all components, wiring, and accessories.

b. Provide comprehensive sequence of operation description of each control system.

c. Provide clearly marked-up manufacturer's data showing compliance with the specifications for all products proposed.

d. Provide all electrical characteristics of components.

6. Record Documents: Reference the requirements detailed in this section.

7. Operation and Maintenance Data: Reference the requirements detailed in this section.

D. Resubmittals of rejected submittals shall be limited to one (1) in number. Costs for processing subsequent resubmittals in excess of the first resubmittal, resulting from the Contractor's disregard of Architect/Engineer's primary submittal rejection comments, shall be borne by the Contractor. Costs shall be based on Architect/Engineer's hourly rates as published in their current professional fee schedules and shall also include reimbursable costs for delivery, mailing, and photocopies at direct cost plus fifteen percent (15%).
1.6 SUBSTITUTIONS

A. The use of manufacturers' names and catalog numbers followed by the phrase "or equal" is generally used to establish a standard of quality and utility for the specified items and to provide a dimensional reference for construction documents that are drawn to scale.

B. Submittals for "equal" items shall, where applicable, include the following data that are not necessarily required for specified items:

1. Performance characteristics.
3. Finish.
5. Manufacturer's specifications and other data needed to prove compliance with the specified requirements. The term "Compliance" is understood to mean that the Contractor certifies that the submitted equipment will meet or exceed the contract document requirements. Items that do not clearly meet this definition should be identified and explained as required in Paragraph 6 below.
6. Identify the difference between the specified item or function and the proposed. Explain with enough detail so that the Architect/Engineer/Owner can easily determine that the item complies with the functional intent. List any disadvantages or advantages of the proposed item versus the specified item. Submit technical data sheets and pictures and diagrams to support and clarify. Include shop drawings for all piping and ductwork equipment per Paragraph 1.5 Submittals. Organize in a clear and concise format.

C. Submittals of "equal" components or systems may be rejected if:

1. The material or equipment would necessitate the alteration of any portion of the mechanical, electrical, architectural or structural design.
2. Dimensions vary from the specified material or equipment in such a manner that accessibility or clearances are impaired or the work of other trades is adversely affected.

D. Proposed substitutions for materials or equipment must be submitted ten (10) days prior to final bid date for consideration as approved equals. Otherwise, such substitutions will not be permitted. Only Prime Bidders are allowed to make proposals for substitutions. Manufacturers, distributors, and sub-contractors shall not make proposals to the Architect/Engineer for substitutions.

E. No substitution shall be made unless authorized in writing by the Architect/Engineer. Should a substitution be accepted, and should the substitute material prove defective or otherwise unsatisfactory for the service intended, and within the guarantee period, replace this material or equipment with material or equipment specified, at no additional cost to
the Architect/Engineer/Owner, and to the satisfaction of the Architect/Engineer.

F. Contractors submitting bids on substitute materials and equipment must also provide a written performance guarantee certifying that the substitute materials and equipment will produce the specified effects and meet the approval of the Architect/Engineer.

1.7 ORDINANCES, PERMITS, AND ROYALTIES

A. Procure all permits and licenses necessary for completion of this project and pay all lawful fees required and necessary pursuant in obtaining said permits and licenses. All required certificates of approvals and inspections by local governing and regulating authorities shall be obtained and paid for by the Contractor.

B. Pay any royalty payments required or fees for the use of patented equipment or systems. Defend all law suits or claims for infringement of any patent rights and shall hold the Owner and Architect/Engineer harmless from loss as a result of said suits or claims.

1.8 COMPATIBILITY OF EQUIPMENT

A. Assume full responsibility for satisfactory operation of all component parts of the mechanical systems to assure compatibility of all equipment and performance of the integrated systems in accordance with the requirements of the specifications. Should the Contractor consider any part of the specifications or drawings as rendering his acceptance of such responsibility impossible, prohibitive, or restrictive, he shall notify the Architect/Engineer before submitting his bid, and the bid shall be accompanied by a written statement of any objections or exceptions to the specifications and drawings.

1.9 EXISTING UTILITIES AND TEMPORARY SERVICES FOR CONSTRUCTION

A. Verify the location and capacity of existing utility services pertaining to work of Division 23. Relocate existing utilities unearthed by excavation as directed by the utility service companies affected.

B. Temporary Services for Construction

1. Provide temporary services in strict accordance with the provisions of these specifications.

1.10 JOBSITE CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed. Include required work to correct conditions detrimental to the timely and proper completion of all Division 23 Work. Do not proceed until unsatisfactory conditions are corrected.

1.11 PREPARATION AND COORDINATION

A. Perform coordination work in strict accordance with provisions of these specifications and the following:

1. Coordinate as necessary with other trades to assure proper and adequate interface with all work.

2. Where ducts, pipes and other mechanical items are shown in conflict with locations of structural members and other equipment, include labor and materials
required for extensions, offsets and supports to clear the encroachment.

3. Although such work is not specifically indicated, provide all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation.

4. Coordinate accepted equipment changes from those scheduled or specified with other trades affected. Additional compensation to other trades for equipment changes is the responsibility of the Contractor making the change.

B. Mechanical Drawings are diagrammatic. Follow the drawings as closely as actual construction and work of other trades will permit. Duct and piping arrangement have been designed for maximum economy consistent with good practice and other considerations. Install the systems arranged as shown on the drawings, except as otherwise approved in advance by the Architect/Engineer.

C. Data indicated on the Drawings and in these Specifications are as exact as could be secured, but their absolute accuracy is not warranted. The exact locations, distances, levels, and other conditions will be governed by actual construction and the Drawings and Specifications should be used only for guidance in such regard.

D. Where items such as diffusers, thermostats, switches, and control panels are not specifically located on the Drawings, provide an RFI to the Architect/Engineer, and locate as determined in the field by the Architect/Engineer. Where such items are installed without such specific direction, relocate as directed by the Architect/Engineer, and at no additional cost to the Architect/Engineer/Owner.

E. Verify all dimensions and distances. No additional compensation will be allowed because of differences between work shown on the Drawings and actual dimensions and distances at the jobsite.

1.12 CONSTRUCTION REQUIREMENTS

A. The drawings show the arrangements of work. Should project conditions necessitate rearrangement, or if the materials or equipment can be installed to a better advantage in a different manner, before proceeding with the work, prepare and submit five copies of Drawings of the proposed arrangement for the Architect/Engineer’s review. Allow a minimum of ten (10) working days for review.

B. Should the Contractor propose to install equipment requiring space conditions other than those shown, or rearrange the equipment, he shall assume responsibility for the rearrangement of the space and shall have the Architect/Engineer review the change before proceeding with the work. The request for such changes shall be accompanied by contractor-generated detailed shop drawings of the space in question. Identify monetary credits proposed or other benefits of the change. Allow a minimum of ten (10) working days for review.

C. Properly locate and size all slots, holes, and openings in the building structure pertaining to the work and for the correct location of pipe sleeves, duct sleeves, fire dampers, etc., as applicable to the work.

1.13 PROJECT RECORD DOCUMENTS

A. Provide the record documents associated with the work of Division 23 in strict accordance with the provisions of these specifications.
B. Throughout progress of the Division 23 Work, maintain an accurate record of changes in the Contract Documents that apply to work of Division 23. Changes shall include all addendums issued during bidding. Maintain an accurate record of the location of mechanical service lines and outlets and all outside utilities.

C. Delegate the responsibility for maintenance of Record Documents to one person on the Contractor's staff as approved by the Architect/Engineer. Submit in writing at the pre-construction conference the name and credentials of the person responsible for record mark-ups and maintenance.

D. Accuracy of Records

1. Thoroughly coordinate changes within the Record Documents, making adequate and proper entries on each page of Specifications and each sheet of drawings and other documents where such entry is required to show the change properly. Match the symbology and format of the base documents.

2. Accuracy of records shall be such that a future verification of items shown in the Contract Documents may rely reasonably on information obtained from the approved Project Record Documents.

E. Maintain the job set of Record Documents completely protected from deterioration and from loss and damage until completion of the work and transfer of all recorded data to the final Project Record Documents.

F. Making Entries on Drawings

1. Using an erasable colored pencil (not ink or indelible pencil), clearly describe the change by graphic line and note as required.

2. Date all entries.

3. Call attention to the entry by a "cloud" drawn around the area or areas affected.

4. In the event of overlapping changes, use different colors for the overlapping changes.

5. Make entries within 24 hours after receipt of information that the change has occurred.

6. Maintain the base drawing format and use the same symbology.

7. Convert field mark-ups to finished CADD record drawings when required in this section.

G. Conversion of Schematic Layouts

1. In some cases on the drawings, arrangements of ductwork and piping and similar items are shown schematically and are not intended to portray precise physical layout. Determine final physical arrangement subject to the Architect/Engineer's approval. However, design of future modifications of the facility may require accurate information as to the final physical layout of items that are shown only schematically on the drawings.
2. Show on the job set of record drawings, by dimension accurate to within one inch, the centerline of each run of items such as all sleeves and piping, etc., below grade, in walls, or in the concrete slab. A surface mounted device indicates the exact location:

a. Clearly identify the item by accurate note such as "Chilled Water" and the like.

b. Show, by symbol or note, the vertical location of the item "under slab," "in ceiling plenum," "exposed," and the like.

c. Make all identification sufficiently descriptive that it may be related reliably to the specifications.

H. Final Project Record Documents

1. The purpose of the final Project Record Documents is to provide factual information regarding all aspects of the Work, both concealed and visible, to enable future modification of the Work to proceed without lengthy and expensive site measurement, investigation, and examination.

2. Provide CADD electronic files in "*.dwg" Format using AutoCAD Release 2015 software (minimum). Upon written request and completion of a release form, the Engineer will provide AutoCAD Release 2015 electronic files of base Contract Drawings in dwg format on compact disc. The Engineer will also provide a list of drawing layers and names that shall be maintained.

3. Provide completed record drawings on CD and one 20# bond reproducible of each drawing.

4. Refer to Section 017700 for additional requirements.

1.14 OPERATION AND MAINTENANCE DATA

A. Well before substantial completion, submit two copies of a preliminary draft of the proposed manual(s) to the Architect/Engineer for review and comments. Allow a minimum of ten (10) working days for review.

B. Submit specified number copies of the approved manual to the Architect/Engineer prior to indoctrination of operation and maintenance personnel.

C. Prepare in accordance with the following standards:

Format:

Size: 8½” x 11”

Paper: White bond, at least 20 lb. weight

Text: Neatly written or printed

Drawings: 11” in height preferable; bind in with text; foldouts acceptable; larger drawings are acceptable but fold to fit within the Manual and provide a drawing pocket inside rear cover or bind in with text.
**Flysheets:** Separate each section of the Manual with neatly prepared flysheets briefly describing contents of the ensuing section; flysheets may be in color.

**Binding:** Use heavy-duty plastic or fiberboard covers with binding mechanism concealed inside the manual; 3-ring binders will be acceptable; all binding is subject to the Architect/Engineer’s approval.

**Measurements:** Provide all measurements in U.S. standard units such as feet-and-inches, lbs, and cfm. Where items may be expected to be measured within ten years in accordance with metric formulae, provide additional measurements in the “International System of Units” (SI).

D. Provide front and back covers for each manual, using durable material approved by the Architect/Engineer, and clearly identified on or through the cover with at least the following information:

1. OPERATING AND MAINTENANCE INSTRUCTIONS
   a. Name and Address of Work
   b. Name of Contractor
   c. General subject of this manual
   d. Space for approval signature of the Architect/Engineer and approval date

E. Contents: Include at least the following:

1. Neatly typewritten index near the front of the manual, giving immediate information as to location within the manual of all emergency information regarding the installation.

2. Complete instructions regarding operation and maintenance of all equipment provided including lubrication, disassembly, and reassembly.

3. Complete nomenclature of all parts of all equipment.

4. Complete nomenclature and part number of all replaceable parts, name and address of nearest vendor, and all other data pertinent to procurement procedures.

5. Copy of all guarantees and warranties issued.

6. Manufacturer’s bulletins, drawings, and descriptive data, clearly indicating the precise items included in this installation and deleting, or otherwise clearly indicating, all manufacturers’ data with which this installation is not concerned.

7. Such other data as required in other sections of these specifications.

1.15 TESTING AND INSPECTION

A. Provide personnel and equipment, make required tests, and secure required approvals
B. Make written notice to the Architect/Engineer, adequately in advance, of each of the following stages of construction:

1. When all rough-in is complete, but not covered;

2. As specified in all Division 23 sections.

3. At the completion of the work of Division 23.

C. When material or workmanship is found to not comply with the specified requirements, remove the noncomplying items from the job site and replace them with items complying with the specified requirements at no additional cost to the Architect/Engineer/Owner. This shall be performed within 3 days after receipt of written notice of noncompliance.

1.16 WARRANTY

A. Warranty all equipment and workmanship for a period of one year after date of substantial completion and replace or repair any faulty equipment or installation at no cost to the Architect/Engineer/Owner for such service during this period, all in accordance with requirements of Division 01.

B. Provide full material warranty on all compressors for a period of five years after date of substantial completion.

C. This warranty shall not void specific warranties issued by manufacturers for greater periods of time. Nor shall it void any rights guaranteed to the Owner by law.

D. Warranties shall be in writing in a form satisfactory to the Owner, and shall be delivered to the Owner before final payment is made.

1.17 PROJECT COMPLETION

A. Upon completion of the work of Division 23, thoroughly clean all exposed portions of the mechanical installation, removing all traces of soil, labels, grease, oil, and other foreign material, and using only the type cleaner recommended by the manufacturer of the item being cleaned.

END OF SECTION
SECTION 23 05 48
VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Elastomeric isolation pads.
   2. Spring hangers.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device type required.

B. Delegated-Design Submittal: For each vibration isolation device.
   1. Include design calculations for selecting vibration isolators.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation for HVAC equipment.

B. Qualification Data: For testing agency.

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Ace Mountings Co., Inc.
b. California Dynamics Corporation.
c. Isolation Technology, Inc.
d. Kinetics Noise Control, Inc.
e. Mason Industries, Inc.
f. Vibration Eliminator Co., Inc.
g. Vibration Isolation.
h. Vibration Mountings & Controls, Inc.

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Ribbed pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: Resilient and elastomeric.
   a. Surface Pattern: Ribbed pattern.
   b. Infused nonwoven cotton or synthetic fibers.

2.2 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ace Mountings Co., Inc.
   b. Kinetics Noise Control, Inc.
   c. Mason Industries, Inc.
   d. Vibration Eliminator Co., Inc.
   e. Vibro-Acoustics.
   f. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
9. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 VIBRATION CONTROL DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

END OF SECTION
SECTION 23 09 23
CONTROL DAMPERS

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section includes control dampers and actuators.

1.3 ACTION SUBMITTALS
A. Product Data: For each type of product, including the following:
   1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
   2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
   4. Installation instructions, including factors affecting performance.

B. Shop Drawings:
   1. Include plans, elevations, sections, and mounting details.
   2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal:
   1. Schedule and design calculations for control dampers and actuators, including the following.
      a. Flow at project design and minimum flow conditions.
      b. Face velocity at project design and minimum airflow conditions.
      c. Pressure drop across damper at project design and minimum airflow conditions.
      d. AMCA 500D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
      e. Maximum close-off pressure.
      f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Product installation location shown in relationship to room, duct, and equipment.
2. Size and location of wall access panels for control dampers and actuators installed behind walls.
3. Size and location of ceiling access panels for control dampers and actuators installed above inaccessible ceilings.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control dampers to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to size products where indicated as delegated design.

C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Environmental Conditions:

1. Provide electric control-damper actuators with protective enclosures. Electric control-damper actuators not available with integral enclosures shall be housed in protective secondary enclosures.

E. Selection Criteria:

1. Control dampers shall be suitable for operation at following conditions:
   a. 5 in. w.g. at 180 deg. F.

2. Dampers shall have stable operation throughout full range of operation, from design to minimum airflow over varying pressures and temperatures encountered.
3. Select modulating dampers for a pressure drop of 2 percent of fan total static pressure unless otherwise indicated.
4. Two-position dampers shall be full size of duct or equipment connection unless otherwise indicated.
2.2 RECTANGULAR CONTROL DAMPERS

A. General Requirements:

1. Unless otherwise indicated, use parallel blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed blade configuration.
2. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.
3. Damper actuator shall be factory installed by damper manufacturer as integral part of damper assembly. Coordinate actuator location and mounting requirements with damper manufacturer.

B. Rectangular Dampers with Aluminum Airfoil Blades:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Greenheck Fan Corp.
   b. Nailor Industries, Inc.
   c. Ruskin Company.
2. Performance:
   a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1-in. wg (250-Pa) differential static pressure.
   b. Pressure Drop: 0.05-in. wg (12.5 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper when tested according to AMCA 500-D, figure 5.3.
   c. Velocity: Up to 6000 fpm (30 m/s).
   d. Temperature: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
   e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
   f. Damper shall have AMCA seal for both air leakage and air performance.
3. Construction:
   a. Frame:
      1) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch (1.8 mm) thick.
      2) Hat-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch (25 mm).
      3) Width not less than 5 inches (125 mm).
   b. Blades:
      1) Hollow, airfoil, extruded aluminum.
      2) Parallel or opposed blade configuration as required by application.
      3) Material: ASTM B 211, Alloy 6063 T5 aluminum, 0.07 inch (1.8 mm) thick.
      4) Width not to exceed 6 inches (150 mm).
      5) Length as required by close-off pressure, not to exceed 48 inches (1200 mm).
   c. Seals:
1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
2) Jambs: Stainless steel, compression type.
d. Axles: 0.5-inch- (13-mm-) diameter stainless steel, mechanically attached to blades.
e. Bearings:
  1) Molded synthetic or stainless-steel sleeve mounted in frame.
  2) Where blade axles are installed in vertical position, provide thrust bearings.
f. Linkage:
  1) Concealed in frame.
  2) Constructed of aluminum and stainless steel.
  3) Hardware: Stainless steel.
g. Transition:
  1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
  2) Factory mount damper in a sleeve with a close transition to mate to field connection.
  3) Damper size and sleeve shall be connection size plus 2 inches (50 mm).
  4) Sleeve length shall be not less than 12 inches (300 mm) for dampers without jackshafts and shall be not less than 16 inches (450 mm) for dampers with jackshafts.
  5) Sleeve material shall match adjacent duct.

2.3 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.

C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.

D. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.

E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

G. Provide mounting hardware and linkages for connecting actuator to damper.

H. Select actuators to fail in desired position in the event of a power failure.
I. Actuator Fail Positions:

1. Refer to the drawings.

2.4 ELECTRIC AND ELECTRONIC ACTUATORS

A. Type: Motor operated, with or without gears, electric and electronic.

B. Voltage:

1. 120V.
2. Actuator shall deliver torque required for continuous uniform movement of controlled
device from limit to limit when operated at rated voltage.
3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

C. Construction:

1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon
bearings, and pressed steel enclosures.
2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in
bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed
in dustproof cast-iron, cast-steel, or cast-aluminum housing.
3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand
crank and permanently lubricated bearings.

D. Field Adjustment:

1. Spring return actuators shall be easily switchable from fail open to fail closed in the field
without replacement.
2. Provide gear-type actuators with an external manual adjustment mechanism to allow
manual positioning of the damper when the actuator is not powered.

E. Two-Position Actuators: Single direction, spring return or reversing type.

F. Position Feedback:

1. Provide a position indicator and graduated scale on each actuator indicating open and
closed travel limits.

G. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or
close) on loss of power.

H. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or
magnetic clutches are acceptable methods of protection.

I. Damper Attachment:
1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

J. Temperature and Humidity:
1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F ((minus 29 to plus 49 deg C)).
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

K. Enclosure:
1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.

L. Stroke Time:
1. Operate damper from fully closed to fully open within 15 seconds.
2. Operate damper from fully open to fully closed within 15 seconds.
3. Move damper to failed position within 15 seconds.
4. Select operating speed to be compatible with equipment and system operation.
5. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

M. Sound:
1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

2.5 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.
1. Wire size shall be at least No. 14 AWG.
2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch (50- to 65-mm) lay.
3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
4. Conductor colors shall be black (hot), white (neutral), and green (ground).
5. Furnish wire on spools.

2.6 RACEWAYS FOR CONTROL WIRING, CABLING, AND TUBING

A. Metal Conduits, Tubing, and Fittings:
1. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. EMT: Comply with NEMA ANSI C80.3 and UL 797.
3. FMC: Comply with UL 1; zinc-coated steel or aluminum.
4. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
5. Fittings for Metal Conduit: Comply with NEMA ANSI FB 1 and UL 514B.
   a. Fittings for EMT:
      1) Material: Steel or die cast.
      2) Type: Setscrew or compression.
   b. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
B. Examine roughing-in for dampers installed in duct systems to verify actual locations of connections before installation.
C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL
A. Furnish and install products required to satisfy most stringent requirements indicated.
B. Properly support dampers and actuators, wiring, and conduit to comply with requirements indicated.
C. Fastening Hardware:
   1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
   2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
   3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
D. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.3 ELECTRIC POWER
A. Furnish and install electrical power to products requiring electrical connections.
3.4 CONTROL DAMPERS

A. Install smooth transitions, not exceeding 15 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:
   1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
   2. Install dampers with at least 24 inches (600 mm) of clear space on sides of dampers requiring service access.

C. Service Access:
   1. Dampers and actuators shall be accessible for visual inspection and service.
   2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."

D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.

E. Attach actuator(s) to damper drive shaft.

F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.5 CONNECTIONS

A. Connect electrical devices and components to electrical grounding system.

3.6 CHECKOUT PROCEDURES

A. Control-Damper Checkout:
   1. Check installed products before continuity tests, leak tests, and calibration.
   2. Check dampers for proper location and accessibility.
   3. Verify that control dampers are installed correctly for flow direction.
   4. Verify that proper blade alignment, either parallel or opposed, has been provided.
   5. Verify that damper frame attachment is properly secured and sealed.
   6. Verify that damper actuator and linkage attachment are secure.
   7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
   8. Verify that damper blade travel is unobstructed.

3.7 ADJUSTMENT, CALIBRATION, AND TESTING:

A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.
B. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressure.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION
SECTION 23 31 13
METAL DUCTS

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Single-wall rectangular ducts and fittings.
   2. Single-wall round ducts and fittings.
   4. Sealants and gaskets.
   5. Hangers and supports.
B. Related Sections:
   1. Section 233300 "Air Duct Accessories" for duct-mounting access doors.

1.3 PERFORMANCE REQUIREMENTS
A. Delegated Duct Design: Duct construction, including seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".
C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of the following products:
   1. Ductwork materials and fittings.
   2. Sealants and gaskets.
B. Shop Drawings:
1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Reinforcement and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Delegated-Design Submittal:

1. Joint and seam construction and sealing.
2. Reinforcement details and spacing.
3. Materials, fabrication, assembly, and spacing of hangers and supports.
4. Design Calculations: Calculations for selecting hangers and supports.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:


B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M; Type 304, cold rolled, annealed, sheet; 10 gauge; surface finish shall be No. 2D (satin) as indicated in the "Duct Schedule" Article.
C. Reinforcement Shapes and Plates: Compatible materials for stainless-steel ducts.

D. Tie Rods: Stainless-steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.4 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Solids Content: Minimum 65 percent.
   5. Mold and mildew resistant.
   6. VOC: Maximum 75 g/L (less water).
   7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
   8. Service: Indoor or outdoor.

C. Flanged Joint Sealant: Comply with ASTM C 920.
   2. Type: S.
   3. Grade: NS.
   5. Use: O.
   6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

E. Round Duct Joint O-Ring Seals:
   1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.
   2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
   3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

C. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports:

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 4 inches.

I. Protect duct interiors from moisture, construction debris and dust, and other foreign materials.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Structural-steel fasteners appropriate for construction materials to which hangers are being attached.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:
2. Test the following systems:
   a. Test duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 DUCT SCHEDULE
A. Wind Tunnel Ductwork:
   1. Type 304, stainless-steel sheet.
      1) No. 2D finish.
      b. Pressure Class: Positive or negative 4-inch wg (1000 Pa).
      c. Minimum SMACNA Seal Class: A.
      d. SMACNA Leakage Class: 3.

B. Intermediate Reinforcement:
   1. Stainless-Steel Ducts:
      a. Exposed to Airstream: Match duct material.
      b. Not Exposed to Airstream: Match duct material.

C. Elbow Configuration:
   1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
      a. Velocity 1000 fpm (5 m/s) or Lower:
         1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
         2) Mitered Type RE 4 without vanes.
      b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s):
         1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
         2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1500 fpm (7.6 m/s) or Higher:
1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
4) Radius-to-Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches (305 mm) and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches (356 mm) and Larger in Diameter: Standing seam.

D. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: Spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION
SECTION 23 33 00
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Flange connectors.
2. Duct-mounted access doors.
3. Flexible connectors.
4. Duct accessory hardware.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.
PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION


B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2D finish for exposed ducts.

B. Reinforcement Shapes and Plates: Compatible materials for aluminum and stainless-steel ducts.

C. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 FLANGE CONNECTORS

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

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Hardcast, Inc.
4. Nexus PDQ.
5. Ward Industries; a brand of Hart & Cooley, Inc.

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Stainless steel.

D. Gage and Shape: Match connecting ductwork.

2.4 DUCT-MOUNTED ACCESS DOORS

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

1. Aire Technologies.
2. American Warming and Ventilating; a Mestek Architectural Group company.
3. Cesco Products; a division of MESTEK, Inc.
4. CL WARD & Family Inc.
5. Ductmate Industries, Inc.
7. Flexmaster U.S.A., Inc.
9. McGill AirFlow LLC.
10. Nailor Industries Inc.
11. Pottorff.
12. Ventfabrics, Inc.


1. Door:
   a. Double wall, rectangular.
   b. Stainless steel with insulation fill and thickness as indicated for duct pressure class.
   c. Hinges and Latches: 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
   d. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Stainless steel with bend-over tabs and foam gaskets.

3. Number of Hinges and Locks:
   a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches (460 mm) Square: Continuous and two sash locks.
   c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Continuous and two compression latches.

2.5 FLEXIBLE CONNECTORS

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

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Duro Dyne Inc.
4. Elgen Manufacturing.
5. Hardcast, Inc.
6. JP Lamborn Co.
7. Ventfabrics, Inc.
8. Ward Industries; a brand of Hart & Cooley, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) wide attached to two strips of 2-3/4-inch (70-mm) wide, 0.028-inch (0.7-mm) thick, galvanized sheet steel or 0.032-inch (0.8-mm) thick aluminum sheets. Provide metal compatible with connected ducts.
   1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
   2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

F. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
   1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
   2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
   7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.

2.6 DUCT ACCESSORY HARDWARE
   A. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

   B. Install duct accessories of materials suited to duct materials; use stainless-steel accessories in stainless-steel ducts.

   C. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
      1. Upstream and downstream from duct filters.
      2. Downstream from control dampers and equipment.
      3. Upstream and downstream from turning vanes.
      4. Upstream or downstream from duct silencers.
      5. Control devices requiring inspection.
      6. Elsewhere as indicated.

   D. Install access doors with swing against duct static pressure.

   E. Install flexible connectors to connect ducts to equipment.
F. For fans developing static pressures of 5-inch wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Inspect locations of access doors and verify that purpose of access door can be performed.

END OF SECTION