SECTION 23 31 00
SHEET METAL WORK AND ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.02 WORK INCLUDED

A. Furnish and install a complete system of air distribution, including accessories, to all areas indicated on the contractor drawings.

B. Create, coordinate and submit ¼" scale Coordination Drawing.

C. Provide all ductwork, fittings and accessories to make a complete and operational system in all respects.

1.03 RELATED SECTIONS

A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.

1.04 REFERENCES

A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.

B. Material standards shall be as specified or detailed hereinafter and as follows:
   1. ASTM A36/A36M – Standard Specification for Carbon Structural Steel.
   2. ASTM A1008/A1008M – Standard Specification for Steel, Sheet, Carbon, Cold Rolled, Commercial Quality.
   3. ASTM A1011/A1011M – Standard Specification for Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Sheet and Strip, Commercial Quality.
   4. ASTM A653/A653M – Standard Specification for Steel Sheets, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot Dip Process.
   5. ASTM B 209 – Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   6. NFPA 90A – Installation of Air Conditioning and Ventilating Systems.
   7. NFPA 90B – Installation of Warm Air Heating and Air Conditioning Systems.
   8. SMACNA (LEAK)– HVAC Air Duct Leakage Test Manual.
   9. SMACNA (DCS)– HVAC Duct Construction Standards – Metal and Flexible.
   10. UL 181 – Factory-Made Air Ducts and Connectors.

1.05 SUBMITTALS

A. See General Conditions for Additional Requirements.

B. Product Data: Provide data for duct materials, duct connectors and all accessories. Include sound attenuator test data in accordance with ASTM E477.

C. The Sheet Metal Contractor shall submit duct fabrication standards and methods of installation, in compliance with SMACNA and these specifications, for review and approval by the Architect, clearly indicating the combination of metal gauges and reinforcement intended for use for each pressure classification. Duct fabrication shall not be allowed until a satisfactory review of this Standard has been performed and fabrication drawings have been reviewed and coordinated.

MERELY SUBMITTING COPIES OF THE SMACNA PRESSURE CLASS TABLES DOES NOT COMPLY WITH THIS REQUIREMENT.

D. Provide scaled ductwork fabrication drawings. Fabrication drawings shall be double line and as a minimum include elevations, dimensions, sizes, all offsets rises and drops, air distribution devices.

E. Provide scaled ductwork coordination drawings for all systems.

F. Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA– HVAC Air Duct Leakage Test Manual.

G. Project Record Documents: Record actual locations of ducts, duct fittings and all accessories. Record changes in fitting location and type. Show additional fittings used.

1.06 QUALITY ASSURANCE

A. All ducts and fittings shall be manufactured by a sheet metal fabrication company whose primary business experience is the manufacture of commercial and industrial quality ducts and fittings. Sheet Metal Contractor shall have adequate experience of building ductwork of the types required for this project as well as successful experience with projects of similar scope. Bids from sheet metal shops which do not meet the specified requirements shall not be acceptable.

B. No Ductmate, Ward, Nixon or similar factory made slip-on connections will be permitted.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Do not install duct sealants when temperature is less than those recommended by sealant manufacturers.

B. Maintain temperatures within acceptable range during and after installation of duct sealants.

1.08 REFERENCE STANDARDS

A. ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2019.

B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2023.

C. ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Required Hardness, Solution Hardened, and Bake Hardenable; 2023, with Editorial Revision.

D. ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength; 2023.

E. ASTM E477 - Standard Test Method for Laboratory Measurements of Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers; 2020.

F. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.

G. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems; 2024.

H. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.

I. SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual; 2012.

J. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; Current Edition, Including All Revisions.

K. UL 555 - Standard for Fire Dampers; Current Edition, Including All Revisions.

L. UL 555S - Standard for Smoke Dampers; Current Edition, Including All Revisions.

PART 2 - PRODUCTS

2.01 SHEET METAL WORK

A. General
   1. Acceptable Manufacturers (Provided they are in compliance with these specifications)
      a. Sheet Metal
         1) All ducts and fittings shall be manufactured by a sheet metal fabrication company whose primary business experience is the manufacture of commercial and industrial quality ducts and fittings. Sheet Metal Contractor shall have adequate experience of building ductwork of the types required for this project as well as successful experience with projects of similar scope. Bids from sheet metal shops which do not meet the specified requirements shall not be acceptable.

B. Sheet Metal Accessories
   1. Access Doors
      a. Ruskin
      b. Air Balance
      c. Buckley Associates
      d. Ductmate
      e. Or approved equal
   2. Flexible Connectors
      a. Ventlock
      b. Elgen Manufacturing
      c. Duro Dyne
      d. Ventglass
      e. Or approved equal
   3. Flexible Ductwork
      a. Clevepak Corp.
      b. Flexible Technologies
      c. Unaflex Rubber Corp.
      d. Flexmaster
      e. Or approved equal
   4. Fire Dampers
      a. Ruskin
      b. Prefco
      c. Air Balance
      d. Greenheck Fan Corp.
      e. Nailor Industries
      f. Or approved equal
   5. NCA Manufacturing Inc.Automatic Dampers Airfoil
      a. Ruskin
      b. Greenheck Fan Corp.
      c. Nailor Industries
      d. T.A. Morrison & Co. Inc. (TAMCO)
      e. NCA Manufacturing Inc.
      f. Or approved equal
   6. Balancing Dampers (OBD)
      a. Ruskin
      b. Young Regulator
      c. Prefco
      d. Greenheck Fan Corp.
      e. Nailor Industries
      f. NCA Manufacturing Inc.

g. Or approved equal

7. Small Balancing Damper less than 48x12
   a. Ruskin
   b. Young Regulator
   c. Ventlock
   d. Duro Dyne
   e. Or approved equal

C. Unless otherwise noted, all supply and exhaust air ductwork of all types shall be constructed of galvanized sheet metal based on the "Pressure Class" indicated in the "Minimum SMACNA Construction Standards" table found hereinafter.

D. The drawings are diagrammatic and indicate the arrangements of the principal apparatus, ductwork and piping and shall be followed as closely as possible. Because of the scale of the drawings, it is not possible to show all offsets, rises, drops, rises, fittings, accessories, etc. The Contractor shall carefully investigate the structure, finish conditions, and the work of other trades affecting the work and arrange ductwork, piping, equipment, accessories, etc. accordingly. Provide the best possible arrangement so as to provide the maximum headroom and access to apparatus while providing the minimum resistance to airflow. This work and any extra fittings and offsets required shall be included in the project without extra charge.

E. In addition to sheet metal ductwork provided under this Contract furnishes and/or install accessories and devices furnished by others. Provide and install miscellaneous sheet metal work including safing, mixing baffles, and blank off panels at unused louver areas.

F. All duct systems specified to be installed under this Contract, shall conform to the drawings, specifications, Standards, details and recommendations of the latest Edition of SMACNA "HVAC Duct Construction Standards - Metal and Flexible"; and "Round and Industrial Duct Construction Standards" (hereinafter referred to as Duct Manual). Where the requirements under this Section exceed the requirements of the Duct Manual, the specification shall govern. Wherever the word "should" appears, replace with the word "shall".

G. The Sheet Metal Contractor shall submit duct fabrication standards and methods of installation, in compliance with SMACNA and these specifications, for review and approval by the Architect, clearly indicating the combination of metal gauges and reinforcement intended for use for each pressure classification. Duct fabrication shall not be allowed until a satisfactory review of this Standard has been performed. MERELY SUBMITTING COPIES OF THE SMACNA PRESSURE CLASS TABLES DOES NOT COMPLY WITH THIS REQUIREMENT.

H. All galvanized steel sheet metal shall conform to ASTM A653/A653M (G-90) having not less than 1.25 oz. of zinc on each side of each square foot of sheet. All other duct materials shall be as hereinafter specified as applicable to this Contract.

I. The Sheet Metal Contractor shall furnish and install all plenums with automatic dampers.

J. The Sheet Metal Contractor shall clean and provide temporary caps on all ductwork during installation to prevent dust, dirt and debris from entering ducts during construction, including during shipping, handling and storage in the field.

K. All shop applied fabrication labels shall be applied to the exterior of the ducts. The Sheet Metal Contractor shall remove any material applied to the inside of the ducts before installation.

2.02 DUCT CONSTRUCTION

A. Duct Construction Schedule
   1. Industrial Class 1: Includes non-abrasive applications, i.e., make-up air, general ventilation.
   2. Systems under positive pressure can be specified as industrial construction when required.

MINIMUM SMACNA CONSTRUCTION STANDARDS						
DUCTWORK LOCATION	**PRESSURE CLASS INCHES W.G.**	**SEAL CLASS**	**LEAKAGE CLASS**	**MATERIAL**	**SOUND LINING**	**TABLE NOTES**
TOILET EXHAUST	**-3**	**A**	**4**	**G-90**	**NO**	**1**
GENERAL EXHAUST	**-3**	**A**	**4**	**G-90**	**NO**	**1**
WITHIN 30'-0" OF EACH SIDE OF EXHAUST FAN (SUCTION & DISCHARGE)	**±3**	**A**	**4**	**G-90**	**YES**	**1**
PLENUMS	**-4**	**A**	**4**	**SAME AS DUCTS**	**AS IN-DICTATED**	**1**
OTHER	**±3**	**A**	**4**	**G-90**	**NO**	**1**

1 DUCTWORK IN THE FOLLOWING LOCATIONS SHALL BE CONSTRUCTED OF ALUMINUM OR STAINLESS STEEL AND CONTINUOUSLY WELDED (JOINTS & SEAMS) AND PITCHED BACK TO THE OUTLETS.

- **WITHIN 15'-0" OF AN OUTSIDE AIR INTAKE.**

2.01 ADDITIONAL CONSTRUCTION REQUIREMENTS

A. Minimum Requirements
   1. The minimum gauge for any steel duct over 2" or under -2" pressure class shall be 24 gauge except when specified heavier.
   2. The minimum thickness of any aluminum duct shall be 0.040".
   3. The minimum diameter of any tie rod shall be 1/2".
   4. The maximum tie rod spacing shall be 42" unless specifically engineered in accordance with the SMACNA Industrial Rectangular Duct Standard.
   5. When tie rods intersect, they shall be welded to each other.
   6. No ductwork shall be constructed to less than ±2" w.g. This means nothing is constructed to a standard between –2” w.g. and +2” w.g.
   7. Duct dimensions indicated are clear inside dimensions. The sheet metal dimensions shall be increased to accommodate internal liner where liner is required.

B. All joints and seams in all ductwork and casings shall be sealed to SMACNA Seal Class “A”. In finished areas, sealing compound shall be neatly applied to exposed ductwork and bands shall be provided over, to cover the sealant.

C. Some SMACNA constructions may not be suitable for the leakage classes specified even though they may meet the pressure class and should not be used.
   1. Seal class A Welded means all welded (i.e. transverse joints, longitudinal seams, spiral seams, fire dampers, volume dampers or any accessories)and in addition it means continuously welded.
   2. All sealants, adhesives and coatings shall be of approved kinds and qualities for each point of application, complying with recommendations for the use and storage.

3. The method of installation and materials for sealing the ductwork shall be submitted by the Sheet Metal Contractor for review and approval by the Architect, as part of the ductwork construction standards and installation submittal.

D. All longitudinal seams in all ductwork in excess of +2" w.g. or less then -2" w.g pressure class shall be made with formed Pittsburgh locks.

E. Grooved seam/flat lock/pipe lock joining methods is restricted to 2" W.G. pressure class only.

F. Button punch-snap lock seams are not to be used.

G. Tie rods shall not be used in any plenum or large duct requiring internal access or use as an access pathway.

H. All ductwork required to be removable shall be companion flanged SMACNA Type T-22 for ductwork constructed to SMACNA Metal Duct Standard and companion flanged in accordance with Industrial Standards for ductwork required to be constructed to Industrial Standards.

I. Elbows
   1. Radius elbows shall be used wherever possible. Where it is impossible or impractical to install a 1.5 times width to centerline radius of elbow (full radius elbow) lesser radii configurations shall be used, each with "radius-proportional" splitter vanes permanently installed within. No radius shall be less than 1.0 times the width. Provide square elbows in rectangular ducts with double thickness vanes with a minimum radius of 4 1/2". Square elbows may only be used when radius elbows will not fit and where specifically approved by the Architect prior to fabrication and/or as required by coordination shop drawings. All offsets shall be of the radium type.

J. Ducts Exposed to Weather
   1. For all ducts exposed to weather, after all ducts and joints are sealed and tested as specified herein, apply all over and around the same areas of possible leakage (joints), an approved sealer system, so that ductwork shall be installed in a manner to result in less then 0.5 leakage class.
   2. Exposed ductwork (Outside air intake plenums) shall be insulated and weather-protected by the Insulation Contractor after the installation is completed and tested.

K. It is the intent of this specification to provide a duct system with minimum resistance to airflow. All take-offs shall be throated and transitions made as gradually as possible. "Bullhead" or sharp take-offs shall not be acceptable.

L. In addition to SMACNA requirements, ductwork in supply systems, ductwork in exhaust systems shall be provided with:
   1. Volume dampers in all branch takeoffs and in all main branches and ducts of all ductwork systems (supply and exhaust) for properly regulating and balancing airflow to all terminal outlets, for all duct sizes, whether shown on the drawings or not. The above requirement is mandatory.

M. All rectangular dampers shall be opposed blade and each shall be controlled by an approved galvanized locking quadrant indicating the damper position, as detailed on the drawings.
   1. Volume dampers installed into ductwork that is specified to be externally insulated shall have extended activator/handle rods with extension bracket such that adjustment of the damper handle will not disturb the insulation.

N. Submit the sheet metal shop drawings to the Balancing Contractor of the project for his review and placement of dampers with the final balancing procedures and requirements in mind.
   1. Coordinate the location and areas with the Balancing Contractor, and fabricate the ductwork system accordingly.
   2. Provide any and all balancing dampers required by the balancing contractor at no additional cost.

O. In addition to SMACNA requirements, all round ductwork, if used in lieu of rectangular supply and exhaust systems shall conform to SMACNA.

1. Round duct shall be manufactured of spiral lock seam. Ductwork up to 12"ø and 2" w.g. pressure class can be manufactured with longitudinal lock seams.
2. All tees shall be conical.
3. All laterals shall be straight.
4. All taps through 10" diameter in size shall have a machine drawn entrance and all fittings shall have longitudinal seams, continuous-welded. Both sides of all welds shall be primed with zinc chromate.
5. All tap entrances shall be free of weld build-up.
6. Elbows in diameters 3" through 10" shall be 2-section stamped or pleated elbows. Larger elbows shall be gored construction. Elbows shall be fabricated to a centerline radius of 1.5 times the diameter. All gored elbows shall be fabricated according to the following schedule:

Elbows	# of Gores
Up to 35°	2
36° to 71°	3
Over 71°	5

7. All field joints in diameters through 48" shall be made with a 2" long slip-fit or sleeve coupling provided assembly is not hindered.
8. Unless specifically noted otherwise or required by special constraints, all elbows on ductwork changing direction from vertical to horizontal shall be 1.5 times radius.

2.02 ACCESS DOORS

A. Provide access doors and frames in all supply and exhaust ductwork as required, to permit access to:
   1. Automatic dampers.
   2. All plenums.
   3. For cleaning and inspection purposes.
   4. Doors shall match material type and gauge of the duct system in which they are installed.
   5. Minimum gauge shall be 22.
   6. Provide a neoprene gasketed around their entire perimeter.
   7. Insulated plenums shall have insulated door
   8. Insulated doors shall be double wall.
   9. Insulation between the metal panels shall be of the same thickness as the duct or panel adjacent to the access doors.
   10. All access doors shall be hung on heavy hinges and shall be secured in the closed position by means of cast zinc clinching type cam latches
   11. Hinged doors shall be similar to Greenheck model HAD-10.
   12. Where space conditions preclude hinges, a minimum of (2) cams shall be utilized in low pressure ductwork and a minimum of (4) heavy window type latches shall be utilized in ductwork over 2” pressure class. In all cases where hinged doors are not utilized, a safety retainer chain shall be provided.
   13. Cammed doors shall be equivalent to Greenheck model CAD-10.
   14. All fire damper access doors in all positive pressure supply ductwork of +3" w.g. or greater construction:
       a. Shall be of the pressure relief (negative pressure) spring loaded type. Design shall incorporate self-closing spring latch or be complete with secure retainer chain and "D" handle.
       b. These doors shall be mounted downstream (after shutoff) of fire dampers.
       c. These doors shall be of the automatic reset type and similar to Ruskin model ADHP-3.

2.03 FLEXIBLE CONNECTIONS (FANS)

A. Provide flexible connections of 4" minimum fabric width
   1. Between ductwork and the inlets and outlets of all fans.
   2. Equipment equipped with fans.

B. The connections shall be placed as close to the equipment as practical except at fan suction connections and the clear gap at rest shall be not less than 3". At fan suction connections, locate flexible duct connection at least 3 duct diameters away from fan inlet connection.

C. There shall be no tension of the fabric under static or dynamic loads

D. All fabric for flexible duct connections to equipment shall be a minimum of 22 oz. glass fabric, double coated with neoprene, fire retardant, waterproof, airtight, and approved by UL, similar to Ventfabrics or Ventglass.

E. Exterior flexible connection shall be insulated type similar to Duro Dyne.

F. Flexible connections shall be fabricated from approved flameproofed fabric conforming to NFPA 90A. Asbestos shall not be acceptable.

G. Flexible connections shall be installed further upstream from fan powered equipment (in the main duct size) to prevent obstruction of the fan inlet due to suction of the fabric into the airstream.

H. Ductwork shall be increased in size where the flexible connections are located to prevent fully drawn in connections from blocking any duct area. Submit detail for review.

2.04 FLEXIBLE DUCTWORK

A. General
   1. Flexible duct runs must not exceed 5'-0" in length. Flexible duct shall not exceed a maximum of 1/2" sag per linear foot when installed horizontally.
   2. Flexible ductwork shall be supported at a maximum spacing of 2'-6", and as detailed on the drawings. Ductwork must not be compressed. Duct elbows must not exceed 45°

B. Flexible Duct (Rigid)
   1. Flexible duct shall be similar to Flexmaster Triple Lock Buck Duct Flexible Air Duct. Flexible duct (insulated) shall be UL 181, Class 0 listed air duct and constructed in accordance with NFPA 90A and 90B. It shall have a smoke/flame spread rating of 50/25.
   2. Triple Lock Buck Duct shall be made from a tape of dead soft aluminum sheet, spiral wound into a tube and spiral corrugated to provide strength and stability. The joint shall consist of a triple lock that is mechanically performed without the use of adhesives to make a durable airtight seam. A double lock is not acceptable.
   3. Insulated flex shall have a gray fire retardant polyethylene outer jacket with an 8 oz. density, 1 1/2" thick fiberglass insulation blanket, factory wrapped.
   4. The flexible duct shall be supported as required.
   5. Flexible ductwork shall be rated at 12" positive pressure. Duct from 3" to 16" shall have a negative pressure 12" and duct from 18" to 20" shall have a negative pressure of 8".
   6. All flexible ducts shall be individually cartoned and labeled for delivery to the job site for maximum protection.
   7. Provide, where indicated in construction greater then +2” or less then –2”, and upstream of supply boxes or downstream of exhaust boxes.

C. Flexible Duct (Fabric)
   1. Flexible duct shall be similar to Flexmaster Type 2. Flexible duct (insulated) shall be UL 181, Class 1 listed air duct and constructed in accordance with NFPA 90A and 90B. It shall have a smoke/flame spread rating of 50/25.
   2. Duct fabric shall be of a heavy duty coated fiberglass cloth fabric. The fabric material shall be mechanically locked to the outside helix. (Use of adhesives to lock fabric in place is unacceptable.) The helix is constructed of corrosive resistant galvanized steel, formed and mechanically locked to the duct fabric on the outside to prevent tearing of the flexible duct.

3. Insulated flex shall have a gray fire retardant polyethylene outer jacket with an 8 oz. density, 1 1/2" thick fiberglass insulation blanket, factory wrapped.
4. The flexible duct shall be supported as required to prevent sagging. Flexible duct with excessive sagging will not be approved.
5. Flexible ductwork shall be rated at 12" positive pressure and 10" negative pressure. Negative pressure for 14"R and 16"R shall be 5" and negative pressure for 18"R shall be 1".
6. All flexible ducts shall be individually cartoned and labeled for delivery to the job site for maximum protection.
7. Provide, where indicated in ±2” duct construction, downstream of supply boxes or upstream of exhaust boxes.

2.05 DAMPERS

A. General

1. The minimum damper requirements shall be as indicated in the following table:

Damper Construction Table						
Type	Approach Velocity (FPM)	Pressure Rating	Instantaneous Pressure Rating	UL 555S Leakage Class	Blade Type	Listing
Fire dampers in ducts greater than +2" w.g. or less than -2" w.g. (FD)	2000	4”w.g.	10” w.g.	N/A	OBD 3V	UL 555 Dynamic
Other fire dampers (FD)	2,000	4" w.g.	8" w.g.	N/A	Curtain or OBD	UL 555 Dynamic
Isolation dampers (at units)	4.500	8" w.g.	20" w.g.	I	Air Foil	
Automatic dampers (AD)	4.500	6" w.g.	14" w.g.	I	Air Foil	N/A
Balancing damper in ducts less than 48" by 12" (VD or as specified)	2,500	2” w.g.	N/A	N/A	OBD	N/A

B. Automatic Dampers

1. See Automatic Temperature Control Specification.

C. Fire Dampers

1. Fire dampers shall be provided as shown on the drawings and wherever Architectural drawings indicate fire rated partitions. Devices shall be of the appropriate service for the partition class into which they are installed. Exact requirements and type of partition shall be coordinated with the Architect.
2. All dampers shall meet the requirements of NFPA 90A and further shall be tested, rated and labeled in accordance with UL 555 (6th Edition).
3. All dampers shall be tested, rated and labeled as "Dynamic Rated" for closure against airflow in the following configuration:
   a. Vertical mount (horizontal airflow):
      Ducted and unducted.

   Note: Static rated dampers shall not be allowed.
4. Each damper shall be rated to close against maximum design airflow at its installed location, with 400 fpm and .5 inch wg. safety factors and against 4" w.g. maximum pressure across the closed damper.
5. All dampers of all ratings and types shall be of the nominal 100% face area type, with blade package and all frame components out of the airstream. These dampers shall include the required oversize enclosures which shall be sealed by the damper manufacturer for the appropriate duct pressure class into which they are installed. All such dampers shall have appropriate rectangular or round duct collars to facilitate connection of mating ductwork. The Contractor shall be responsible for any additional sealing of duct collars and connections required to maintain the duct seal class requirements but shall not jeopardize the UL breakaway connection when utilized.
6. The Contractor shall indicate the location and rating of all dampers on his shop drawings and shall provide access doors at each location of sufficient size and type to permit access to the damper components. A list of fire dampers shall be provided for review. The Contractor shall be solely responsible to coordinate all locations of duct access doors and dampers of all types.
7. Contractor shall include damper manufacturer's installation instructions as part of the damper submittal. These instructions shall describe the applicable requirements for damper sleeve thickness; retaining angles; sealing; duct-to-sleeve connections; preparation of wall, floor or ceiling openings; and all other requirements to provide an installation equivalent to that tested by the damper manufacturer during the UL 555,qualification procedures. Contractor shall detail any proposed installations that deviate from these manufacturer's instructions and explain the needed deviations. All fire damper installations shall comply with the manufacturer's installation instructions. Any submitted deviations must be acceptable to the appropriate authority having jurisdiction.
8. Fire Dampers
   a. Fire dampers shall be provided as shown on the drawings and wherever Architectural drawings indicate fire-rated partitions.
   b. Fire damper sleeves shall be manufactured with a metal sleeve of appropriate length and thickness for the required damper installation as shown in the table below:

Maximum Duct I.D.	Sleeve Gauge (U.S.)
Up to 84”	20 gauge

   c. Fusible link temperature rating for all fire dampers shall be 212°F or 50°F above the highest system temperature, whichever is greater.
   d. Dampers in stainless steel ducts shall be stainless steel.

PART 3 - EXECUTION

3.01 SHEET METAL INSTALLATION

A. All ductwork shall be installed to true alignment, generally parallel or perpendicular to adjacent building walls, floors and ceilings, so as to present a neat and workmanlike appearance. All

fabricated, stored and installed ductwork shall be protected with removable caps, plastic or other means to prevent dirt, water and debris from entering duct system. The Sheet Metal Contractor shall be responsible for maintaining a clean duct system and shall clean and/or replace any ductwork identified by the Owner or Architect as being deficient or dirty. The Sheet Metal Contractor shall be responsible for all costs associated with the temporary protection cleaning and/or replacement of ductwork. All fabrication labels shall be applied to the exterior of the duct. The Sheet Metal Contractor shall be responsible for the removal of all internal labels if such labels were incorrectly applied.

B. Care shall be paid to the exact locations of all sheet metal work with respect to equipment, ducts, conduits, piping, slabs, beams, columns, ceiling suspension systems, lighting fixtures and electrical, plumbing and fire protection systems in the building. Close coordination and cooperation shall be exercised with other Trades in locating the piping and equipment in the best interests of the Owner. The drawings and specifications covering other work to be done in the building shall be carefully studied and arrangements shall be made to avoid conflict.

C. The drawings shall be followed where they are definite and provided such procedures do not cause objectionable conditions for equipment provided installed under this Contract. The drawings are intended to indicate the sizes of ductwork and if certain sizes are omitted or unclear, obtain additional information before proceeding.

D. Locate and size all openings for ductwork in the building construction. Provide all sleeves as hereinbefore specified.

E. Provide access doors in ductwork at the following locations:
   1. Fire dampers
   2. Both sides of automatic dampers
   3. Otherwise indicated or specified

F. Provide labels with a minimum of 1" high red letters on white background. Each access door shall be labeled as follows (or worded as required by Code):
   1. Fire Damper
   2. Automatic Damper.

G. The installation of special items of equipment in the duct systems, including automatic dampers, thermostats, thermometers, duct airflow measuring devices and other related controls, shall be done by this Contractor under the direct supervision of the manufacturer of such controls.

H. All elbows, tees and branch takeoffs in round ductwork shall be made of the same materials as the ductwork.

I. Duct connections to equipment shall be in no case smaller than the equipment openings.

J. All openings for pitot tube traverses shall be fitted with neat removable plugs or caps. As a minimum, such openings shall be provided at every fan inlet and at such other points as may be required for airflow measuring and balancing. Coordinate the location of plugs and caps with the Balancing Contractor.

K. Provide other miscellaneous sheet metal work shown on the drawings including blanking off portions of louvers not required for the specific usage and diffusion plates or mixing air scoops to allow for air mixing where job conditions require the provision of same. All above work shall be provided as part of this Contract at no extra cost to the Owner.

L. Where applicable and as approved by the Architect, all exposed ductwork shall be installed in a workmanlike manner to result in a neat appearance with no visible penetrations, screws, or other sheet metal imperfections.

M. Install all UL classified devices in accordance with their UL approved installation sheets.

N. Counterflashing of duct penetrations through roof shall be provided under this Contract.

3.02 DUCT HANGERS AND SUPPORTS

A. Provide suitable angle iron/strap hangers and supports in ceilings of the buildings, and on the roof(s) as shown on the drawings (Architectural/HVAC). This work shall be performed as required by job conditions and as instructed by the Architect in the field to support all air distribution ductwork and devices in both horizontal and vertical planes.

B. When hanging and supporting the ductwork, the following shall be complied with:
   1. Except as otherwise noted, ductwork up to 42" in greatest dimension shall be hung by using sheet metal bands secured as a minimum at (2) locations to the vertical sides of the ductwork and at (1) location under the duct. All support systems shall be compatible with the building structure and roofing system as approved by the Architect.
   2. Ductwork shall be securely attached to the building construction. The hanger design and spacing shall be governed by the major duct dimension and shall be in accordance with SMACNA Duct Manual, except as modified hereinbefore. Vertical ductwork shall be supported at each floor level in an approved manner using angles or channels attached to the ducts. The installation, when complete and under operating conditions, shall be free from chatter or vibration. If necessary to achieve this, additional supports and/or bracing shall be furnished without extra cost to the Owner. Supports and bars and similar items shall be primed and painted structural steel. Touch up with aluminum paint any surfaces where galvanizing is destroyed on indoor ductwork, zinc primer on exposed ductwork with a final coat of aluminum paint. Provide vibration isolation hangers where specified under Vibration Isolation Section of these specifications.
   3. The Sheet Metal Contractor shall provide all supplemental steel required to support the ductwork.
   4. The maximum hanger spacing shall be 10'-0" on centers and additionally on each side of an elbow or change-in-direction fitting.
   5. In addition to the above, provide supports on each side of any duct mounted device, coils, flow measuring stations, framed dampers, etc., to permit removal of the device without disconnecting adjacent duct sections.
   6. Provide angle sway bracing to the structure wherever lateral loads would be imposed on the ductwork, including but not limited to:
      a. Elbows downstream of fan discharges.

3.03 SHEETMETAL TESTING

A. General
   1. All ductwork that is required to be tested shall be tested on regular intervals as the job proceeds and shall be completed prior to enclosure in shafts, above ceilings or behind walls.
   2. The Sheet Metal Contractor shall keep an up-to-date log of the ductwork tested for review by the Architect. The Sheet Metal Contractor shall notify all other Contractors when the testing is completed and accepted to permit enclosure of ducts.
   3. The Sheet Metal Contractor shall furnish and install all blank off plates, blind flanges, safing, etc., necessary to isolate each section of duct being tested for leakage.
   4. The Sheet Metal Contractor shall submit for review all proposed testing procedures, sample report, and equipment to the Engineer prior to proceeding. Additionally, the Sheet Metal Contractor shall notify the Engineer when testing is to occur so that the test can be witnessed at the Engineer's option.
   5. All test equipment shall be calibrated per ANSI Standards prior to testing. Certified test reports shall be submitted to the Architect prior to commencement of the testing.
   6. Testing Procedure
      a. The testing procedure shall be in accordance with SMACNA "HVAC Air Duct Leakage Test Manual".
      b. The test pressure shall be the specified construction pressure of the duct system.
   7. Scope of Testing

a. All ductwork (regardless of pressure class) that will be in inaccessible areas including, but not limited to, all ducts within shafts, above hard ceilings, and those that will be made inaccessible by the work of other Trades. (This shall include ±2" w.g. construction.)
b. All ductwork constructed to greater than +2" w.g. or less than -2" w.g.
c. All other sheet metal in duct systems constructed to ±2" w.g. shall be tested under normal fan pressure and shall not leak sufficiently to cause audible leaks or blowing detectable by hand. If, in the opinion of the Architect, the ductwork does not appear to be constructed and/or sealed to the approved shop standards, the Architect may request any or all of this ductwork to be tested at the specified construction pressure.
d. Allowable Leakage
    1) The total allowable leakage shall be less than specified leakage class with no audible leaks.
    2) If no leakage class is listed elsewhere, the system shall meet leakage Class 4.

3.04 DUCT CLEANING

A. Clean dust and debris from interior and exterior of all ducts using wet rags and vacuums.

B. Cover open ends of ductwork when installation does not proceed for more than one day. This requirement shall apply to each individual run of duct, such that no duct section shall remain open or unconnected for more than 8 hours.

END OF SECTION 23 31 00 23 31 00