
USACE / NAVFAC / AFCEA / NASA UFGS-23 31 11.12 40 (June 2006)

Preparing Activity: NASA Superseding
 UFGS-23 31 11.12 40 (April 2006)
 NASA-15818S (December 2005)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 9 October 2006

Latest change indicated by CHG tags

SECTION TABLE OF CONTENTS

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING

SECTION 23 31 11.12 40

DUCTS, MEDIUM/HIGH PRESSURE

06/06

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 DESIGN REQUIREMENTS
- 1.3 SCOPE OF WORK
- 1.4 SUBMITTALS
- 1.5 GENERAL REQUIREMENTS
- 1.6 DRAWINGS

PART 2 PRODUCTS

- 2.1 MATERIALS
 - 2.1.1 Galvanized Steel Ductwork Materials
 - 2.1.2 Brazing Materials
 - 2.1.3 Mill-Rolled Reinforcing and Supporting Materials
- 2.2 COMPONENTS
 - 2.2.1 Round Sheet Metal Duct Fittings
 - 2.2.2 Round, High-Pressure, Double-Wall Sheet Metal Ducts
 - 2.2.3 Duct and Fitting Gages
 - 2.2.4 Reinforcement
 - 2.2.5 Fittings
 - 2.2.6 Turning Vanes
 - 2.2.7 Dampers
 - 2.2.8 Sound Traps
 - 2.2.9 Flexible Connectors for Sheet Metal

PART 3 EXECUTION

- 3.1 PREPARATION
- 3.2 INSTALLATION
- 3.3 APPLICATION
 - 3.3.1 Rectangular Sheet Metal Ducts
 - 3.3.1.1 Medium-Pressure Gages, Joints, and Reinforcement

- 3.3.1.2 Medium- and High-Pressure Branches, Inlets, Outlets
- 3.3.1.3 High-Pressure Gages, Joints, and Reinforcement
- 3.3.2 Round Sheet Metal Ducts
 - 3.3.2.1 Duct Gages, Joints, and Reinforcement
 - 3.3.2.2 Duct Transitions
- 3.3.3 Round, High Pressure, Sheet Metal Duct Installation
 - 3.3.3.1 Joints
 - 3.3.3.2 Insulation Ends
- 3.3.4 Transverse Reinforcement Joints
- 3.3.5 Joint Gaskets
- 3.3.6 Radius Elbows
- 3.3.7 Plenum Connections
- 3.3.8 Access Openings
- 3.3.9 Duct Supports
- 3.3.10 Flexible Connectors for Steel Metal
- 3.3.11 Insulation Protection Angles
- 3.3.12 Duct Probe Access
- 3.3.13 Openings in Roofs and Walls
- 3.4 FIELD QUALITY CONTROL
 - 3.4.1 Fire Damper Tests
 - 3.4.2 Ductwork Leakage Tests
 - 3.4.3 Inspection
- 3.5 DUCTWORK CLEANING PROVISIONS
- 3.6 OPERATION AND MAINTENANCE

-- End of Section Table of Contents --

PART 1 GENERAL

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360 (2005) Specification for Structural Steel Buildings, with Commentary

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE-03 (2005) Handbook, Fundamentals (IP Edition)

ASHRAE-04 (2005) Handbook, Fundamentals (SI Edition)

ASHRAE-06 (2004) Handbook, HVAC Systems and Equipment (IP Edition)

ASHRAE-07 (2004) Handbook, HVAC Systems and Equipment (SI Edition)

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M (1992; R 2004) Specification for Filler Metals for Brazing and Braze Welding

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M (2002) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A 36/A 36M (2005) Standard Specification for Carbon

Structural Steel

ASTM A 653/A 653M	(2004a) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A 924/A 924M	(2004) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM C 1071	(2000) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM D 257	(1999; R 2005) Standard Test Methods for D-C Resistance or Conductance of Insulating Materials
ASTM E 90	(2004) Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2002) Standard for the Installation of Air Conditioning and Ventilating Systems
----------	--

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1481	(1995e2) HVAC Duct Construction Standards - Metal and Flexible
SMACNA 1741	(2004e6) HVAC Duct Systems Inspection Guide, CADD Version 2.0

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS 2480	(2001) Phosphate Treatment, Paint, Base
--------------	---

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC-01	(1993, 3rd Ed) Good Painting Practice Steel Structures Painting Manual, Volume 1
---------	--

1.2 DESIGN REQUIREMENTS

NOTE: If Section 23 00 00.00 40 HEATING, VENTILATING, AND AIR-CONDITIONING is not included in the project specification, applicable requirements therefrom should be inserted and the first paragraph deleted. If Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT is not included in the project specification, applicable requirements therefrom should be inserted and the second paragraph deleted. If Section 23 31 13.20 40 WELDING METAL DUCTWORK is not

included in the project specification, applicable requirements therefrom should be inserted and the third paragraph deleted.

[Section 23 00 00.00 40 HEATING, VENTILATING, AND AIR-CONDITIONING apply to work specified in this section.]

[Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT applies to work in this section.]

[Section 23 31 13.20 40 WELDING METAL DUCTWORK applies to work specified in this section.]

Equipment and Performance Data shall be submitted for medium/high pressure ductwork systems consisting of use life, system functional flows, safety features, and mechanical automated details. Curves indicating tested and certified equipment response and performance characteristics shall also be submitted.

Design Analysis and Calculations shall be submitted for medium/high pressure ductwork systems indicating the manufacturer's recommended air velocities, maximum static pressure, and temperature calculations.

1.3 SCOPE OF WORK

High velocity systems shall encompass ductwork where:

Minimum air velocity exceeds 10 meter per second 2,000 feet per minute (fpm) or static pressure exceeds 500 pascal 2 inches water gage (wg).

[Medium static pressure ranges from over 500 pascal through 750 pascal 2 inches wg through 3 inches wg, positive or negative, or over 750 pascal through 1500 pascal 3 inches wg through 6 inches wg positive.]

[High static pressure ranges from over 1500 pascal through 2500 pascal 6 inches wg through 10 inches wg, positive.]

1.4 SUBMITTALS

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G"

designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists and Records of Existing Conditions shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

SD-02 Shop Drawings

The following shall be submitted in accordance with paragraph entitled, "Drawings," of this section.

Connection Diagrams
Fabrication Drawings
Installation Drawings
Record Drawings

SD-03 Product Data

Equipment and Performance Data shall be submitted for medium/high pressure ductwork systems in accordance with paragraph entitled, "Design Requirements," of this section.

Manufacturer's catalog data shall be submitted for the following items:

Galvanized Steel Ductwork Materials
Brazing Materials
Mill-Rolled Reinforcing and Supporting Materials
Round Sheet Metal Duct Fittings
Round, High-Pressure, Double-Wall Sheet Metal Ducts
Turning Vanes
Dampers
Sound Traps
Flexible Connectors

SD-05 Design Data

[Design Analysis and Calculations](#) shall be submitted for medium/high pressure ductwork systems in accordance with paragraph entitled, "Design Requirements," of this section.

[SD-06 Test Reports](#)

Test reports shall be submitted for medium/high pressure ductwork systems in accordance with the paragraphs entitled, "Ductwork Leakage Tests" and "Fire Damper Tests," of this section.

[Ductwork Leakage Tests](#)
[Operational Tests](#)

[SD-07 Certificates](#)

[Listing of Product Installations](#) for medium/high pressure ductwork systems in accordance with paragraph entitled, "Installation," of this section.

Certificates shall be submitted, showing conformance with the referenced standards contained in this section for:

[Galvanized Steel Ductwork Materials](#)
[Brazing Materials](#)
[Mill-Rolled Reinforcing and Supporting Materials](#)
[Round Sheet Metal Duct Fittings](#)
[Round, High-Pressure, Double-Wall Sheet Metal Ducts](#)
[Turning Vanes](#)
[Dampers](#)
[Sound Traps](#)
[Flexible Connectors](#)

[SD-10 Operation and Maintenance Data](#)

[Operation and Maintenance Manuals](#) shall be submitted in accordance with paragraph entitled, "Operation and Maintenance," of this section.

1.5 GENERAL REQUIREMENTS

[Records of Existing Conditions](#) shall be submitted consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work shall constitute acceptance of existing conditions.

[Material, Equipment, and Fixture Lists](#) shall include the manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

1.6 DRAWINGS

[Connection Diagrams](#) shall be submitted for medium/high pressure ductwork systems indicating the relation and connection of devices and apparatus by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

[Fabrication Drawings](#) shall be submitted for medium/high pressure ductwork systems consisting of fabrication and assembly details to be performed in

the factory.

[Installation Drawings](#) shall be submitted for medium/high pressure ductwork systems. Drawings shall show details of equipment room layout and design.

[Record Drawings](#) shall provide current factual information including deviations from, and amendments to, the drawings and concealed or visible changes in the work, for medium/high pressure ductwork systems.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 [Galvanized Steel Ductwork Materials](#)

Galvanized steel ductwork sheet metal shall be carbon steel, of lock-forming quality, hot-dip galvanized, with regular spangle-type zinc coating, conforming to [ASTM A 924/A 924M](#) and [ASTM A 653/A 653M](#), Designation G90. Duct surfaces to be painted shall be treated by phosphatizing.

Sheet metal [thickness gages](#) and reinforcement thickness shall conform to [ASHRAE-07](#) [ASHRAE-06](#), Chapter 16, [ASHRAE-04](#)[ASHRAE-03](#), Chapter 32 and [SMACNA 1481](#).

2.1.2 [Brazing Materials](#)

Brazing materials shall be silicon bronze conforming to [AWS A5.8/A5.8M](#).

2.1.3 [Mill-Rolled Reinforcing and Supporting Materials](#)

Mill-rolled structural steel shall conform to [ASTM A 36/A 36M](#) and, wherever in contact with sheet metal ducting, shall be galvanized to commercial weight of zinc or coated with materials conforming to [ASTM A 123/A 123M](#) [[SSPC-01](#)].

Equivalent strength, proprietary design, rolled-steel structural support systems may be submitted for approval in lieu of mill-rolled structural steel.

2.2 COMPONENTS

2.2.1 [Round Sheet Metal Duct Fittings](#)

Fittings shall be shop fabricated.

Fittings shall be manufactured as separate fittings, not as tap collars welded or brazed into duct sections.

Offset configurations shall be submitted for approval.

Miter elbows shall be two-piece type for angles less than 31 degrees, three-piece type for angles 31 through 60 degrees, and five-piece type for angles 61 through 90 degrees. Centerline radius of elbows shall be 1-1/2 times fitting cross section diameter.

Crosses, increasers, reducers, reducing tees, and 90-degree tees shall be conical type.

Cutouts in fitting body shall be equal to branch tap dimension or, where

smaller, excess material shall be flared and rolled into smooth radius nozzle configuration.

2.2.2 Round, High-Pressure, Double-Wall Sheet Metal Ducts

Ducts and fittings shall be shop fabricated.

Construction shall comprise an airtight, vapor barrier, outer pressure shell, a 25 millimeter 1 inch insulation layer, and a perforated-metal inner liner that completely covers the insulation throughout the system.

Insulation shall conform to NFPA 90A and ASTM C 1071. Thermal conductivity shall be in accordance with ASTM D 257.

2.2.3 Duct and Fitting Gages

Outer pressure shell shall be as specified in ASHRAE-07, ASHRAE-06 Chapter 16, ASHRAE-04 ASHRAE-03, Chapter 32 and SMACNA 1481; the inner liner shall be as recommended by the manufacturer but not lighter than 0.55 millimeter 26-gage.

Perforations shall be 2.5 millimeter 3/32 inch diameter, and the open area shall be 13 percent.

2.2.4 Reinforcement

Inner liners of both duct and fittings shall be supported by metal spacers welded in position to maintain spacing and concentricity.

2.2.5 Fittings

Divided flow fittings shall be made as separate fittings, not tap collars into duct sections, with the following construction requirements:

Sound, airtight, continuous welds at intersection of fitting body and tap

Tap liner securely welded to inner liner, with weld spacing not to exceed 75 millimeter 3 inches

Insulation shall be packed around the branch tap area for complete cavity filling.

Branch connection shall be carefully fit to cutout openings in inner liner without spaces for air erosion of insulation and without sharp projections that cause noise and airflow disturbance.

Seams in the pressure shell of fittings shall be continuously brazed. Galvanized areas that have been damaged by welding shall be protected with manufacturer's standard corrosion-resistant coating.

Offset configurations shall be submitted for approval.

Elbows shall be two-piece type for angles through 35 degrees, three-piece type for angles 36 through 71 degrees, and five-piece type for angles 72 through 90 degrees.

NOTE: Delete the following paragraph if

low-friction loss thru conical fittings is not a design factor.

[Crosses, increasers, reducers, reducing tees, and 90-degree tees shall be conical type.]

2.2.6 Turning Vanes

Turning vanes shall be double-wall type, commercially manufactured for high-velocity system service.

2.2.7 Dampers

Low pressure drop, high-velocity manual volume dampers, and high-velocity fire dampers shall be constructed in accordance with ASHRAE-07 ASHRAE-06, Chapter 16, ASHRAE-04 ASHRAE-03, Chapter 32 and SMACNA 1481.

2.2.8 Sound Traps

[Sound traps shall be provided.]

NOTE: Retain for high-velocity, high-pressure systems or delete when not applicable to the project.

Drawings must supplement following specifications with data sufficient for the manufacturer to properly select sound traps. Data must include cubic meter per secondfeet per minute; total static pressure; maximum permissible static pressure drop; air movement data (AMD) configuration; system velocities; type motor if in airstream; sound power level measurement point, in millimeter feet, from terminus where applicable; etc.

Indicate sound traps for all fans operating at static pressures in excess of 1000 pascal 4-inches water gage. Traps shall be provided at fan discharge and inlet where required, also in return air systems.

No standards exist for testing prefabricated sound traps. ASTM E 90 is based on static methods. Rewrite where acoustic testing is based on dynamic insertion loss method.

Sound traps shall be factory fabricated, and acoustic confirmation of cataloged attenuation shall be made by an independent laboratory in accordance with ASTM E 90. Pressure drop measurements shall be confirmed in accordance with ASHRAE-07 ASHRAE-06, Chapter 18. Noise-reduction data shall include effects of flanking paths and vibration transmission. Testing shall be with standard metal inlet and outlet connections under indicated capacity flow.

NOTE: Select the following paragraph when sound attenuation in decibels (dB) RE 0.0002 microbar is

given under the following paragraph for each
midfrequency for all octave bands.

Attenuation required should provide present and
future needs at least 5 dB excess attenuation in the
250 hertz, third octave band, midfrequency, when
compared to specified noise criteria curve for the
area.

[Attenuation shall be in accordance with [ASHRAE-04](#) [ASHRAE-03](#).
Certification shall include a graphic system noise spectrum indicating
proposed fan sound power level. Attenuation of ducting system proposed for
installation based on [ASHRAE-03](#) for bends, branches, and other duct system
construction details; sound pressure level without sound trap; attenuation
required; and excess attenuation compared to specific noise criteria curve.]

NOTE: Select the following paragraph only when no
noise criteria are given and when required by
project conditions; otherwise determine performance
criteria after analysis of fans and downstream duct
work.

[Sound trap shall reduce fan-rated sound-power level to not less than 65
decibels in the 250-hertz third octave band when measured at trap discharge
end.]

Pressure drop at rated flow shall not exceed ratings in accordance with
[ASHRAE-07](#) [ASHRAE-06](#), Chapter 16, [ASHRAE-04](#) [ASHRAE-03](#), Chapter 32 and
[SMACNA 1481](#) or design criteria.

Trap shall be airtight when operating under an internal pressure of [2600](#)
[pascal](#) [0.37 pound per square inch](#). Air-side surface shall be capable of
withstanding air velocities of [50 meter per second](#) [10,000 feet per minute](#)
without any particulate matter leaving the trap and being carried
downstream.

Sound traps shall be double-metal walled, [round] [rectangular]. Sheet
metal shall be mill-galvanized steel with commercial weight of zinc,
conforming to [ASTM A 653/A 653M](#). Exterior metal shall act as a vapor
barrier, and metal thickness shall be not less than that required for the
pressure service, in accordance with [ASHRAE-07](#) [ASHRAE-06](#), Chapter 16,
[ASHRAE-04](#) [ASHRAE-03](#), Chapter 32 and [SMACNA 1481](#), but not less than [0.85](#)
[millimeter](#) [22-gage](#). Absorbing material, on the sound-impinging side, shall
be covered with formed perforated mill-galvanized steel of not less than
[0.70 millimeter](#) [24-gage](#). Exterior sheet joints shall be continuously
welded or made with lockseams filled, prior to forming, with a chloroprene
mastic.

Interior surfaces shall be spot welded not more than [75 millimeter](#) [3 inches](#)
on center. Connections to duct transitions shall be flanged with
through-bolted [3 by 25 millimeter](#) [1/8 inch by 1 inch](#) continuous rubber
gasketing. Supports shall be trapeze type, vibration isolated.

Absorption material shall be fibrous glass. [Surface exposed to airstream
shall be chloroprene coated or protected with woven fibrous-glass cloth
conforming to [ASTM C 1071](#).] Total compressed thickness shall provide

required attenuation and thermal insulation to preclude condensation on exterior surface under operating conditions normal to installed location. Compressed material density shall be approximately 72 kilogram per cubic meter 4.5 pounds per cubic foot. Material shall conform to fire hazard requirements of NFPA 90A.

[Round, high pressure, double-walled, internally insulated duct and fittings may be provided in lieu of sound traps when requirements specified herein are complied with.]

2.2.9 Flexible Connectors for Sheet Metal

Connectors shall be UL listed, 915 gram per square meter 30-ounce per square foot, waterproof, fire-retardant, airtight, woven fibrous-glass cloth, double coated with chloroprene. Clear width, not including clamping section, shall be 150 to 200 millimeter 6 to 8 inches.

[Leaded vinyl sheet shall be provided as a second layer for sound attenuation. Leaded vinyl shall be not less than 1.4 millimeter 0.055 inch thick, shall weigh not less than 4.25 kilogram per square meter 0.87 pound per square foot, and shall be capable of approximately 10-decibel attenuation in the 10- to 10,000-hertz range.]

PART 3 EXECUTION

3.1 PREPARATION

Sheet metal construction shall be provided in accordance with the recommendations for best practices in ASHRAE-07 ASHRAE-06, Chapter 16, SMACNA 1481, NFPA 90A, and ASHRAE-04 ASHRAE-03, Chapter 32.

Where construction methods for certain items are not described in the referenced standards or herein, the work shall be performed in accordance with recommendations for best practice defined in ASHRAE-07 ASHRAE-06.

Sheet metal surfaces to be painted and surfaces to which adhesives are to be applied shall be clean and free of oil, grease, and deleterious substances.

Duct strength shall be adequate to prevent failure under service pressure or vacuum created by fast closure of duct devices. Leaktight, automatic relief devices shall be provided.

Supplementary steel shall be designed and fabricated in accordance with AISC 360.

3.2 INSTALLATION

Listing of Product Installations for medium/high pressure ductwork systems shall include identification of at least 5 units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. List shall include purchaser, address of installation, service organization, and date of installation.

Fabrication shall be airtight and shall include reinforcements, bracing, supports, framing, gasketing, sealing, and fastening to provide rigid construction and freedom from vibration, airflow-induced motion and noise, and excessive deflection at specified maximum system air pressure and velocity.

Where ducts pass through firewalls, a flanged duct segment with fire damper and access door shall be provided in that surface during surface construction.

NOTE: Retain only the following sub-parts covering duct types required for the project.

3.3 APPLICATION

3.3.1 Rectangular Sheet Metal Ducts

3.3.1.1 Medium-Pressure Gages, Joints, and Reinforcement

Minimum sheet metal gages, joints, and reinforcements between joints shall be in accordance with [ASHRAE-07](#) [ASHRAE-06](#), Chapter 16, [ASHRAE-04](#) [ASHRAE-03](#), Chapter 32 and [SMACNA 1481](#).

Sheet metal minimum thickness, transverse reinforcement between joints, and joints of ducts shall be in accordance with the following:

LONGEST SIDE (mm)	SHEET METAL THICKNESS ALL SIDES	COMPANION ANGLE (mm)	REINFORCEMENT ANGLES INCHES, 600 (mm) ON CENTER MAXIMUM (BACK TO BACK)
2450 to 2750	1.6	50 by 50 by 3, two tie rods along angle	Two 50 by 50 by 3, two tie rods along angle
2451 to 3350	1.6	50 by 50 by 5, two tie rods along angle	Two 50 by 50 by 5, two tie rods along angle
3351 and longer	2.0	50 by 50 by 5, with tie rods every 1200 mm	Two 50 by 50 by 5, with tie rods every 1200 mm
LONGEST SIDE INCHES	SHEET METAL GAGE ALL SIDES	COMPANION ANGLE INCHES	REINFORCEMENT ANGLES INCHES, 24 INCHES ON CENTER MAXIMUM (BACK TO BACK)
97 to 108	16	2 by 2 by 1/8, two tie rods along angle	Two 2 by 2 by 1/8, two tie rods along angle
109 to 132	16	2 by 2 by 3/16, two tie rods along angle	Two 2 by 2 by 3/16, two tie rods along angle

LONGEST SIDE INCHES	SHEET METAL GAGE ALL SIDES	COMPANION ANGLE INCHES	REINFORCEMENT ANGLES INCHES, 24 INCHES ON CENTER MAXIMUM
(BACK TO BACK)			
133 and longer	14	2 by 2 by 3/16, with tie rods every 48 inches	Two 2 by 2 by 3/16, with tie rods every 48 inches

3.3.1.2 Medium- and High-Pressure Branches, Inlets, Outlets

Branches, inlets, and outlets shall be installed to minimize air turbulence and to ensure proper airflow.

Dampers shall be installed so that the amount of air entering duct mains can be adjusted.

Commercially manufactured air extractors shall be provided to allow adjustment of the air quantity and to provide an even flow of air across the device or duct served.

Where a duct branch is to handle over 25 percent of the air handled by the duct main, a complete 90-degree increasing elbow shall be used, with an inside radius of 0.75 times duct branch width. Size of the trailing end of the increasing elbow within the main duct shall be in the same ratio to the main duct size as the ratio of the relative air quantities handled.

Where a duct branch is to handle 25 percent or less of the air handled by the duct main, the branch connection shall have an inside radius of 0.75 times branch duct width, a minimum arc length of 45 degrees, and an outside radius of 1.75 times duct branch width. Arc shall be tangent to duct main.

3.3.1.3 High-Pressure Gages, Joints, and Reinforcement

Sheet metal minimum thickness, joints, and reinforcement between joints shall be in accordance with [ASHRAE-07](#) [ASHRAE-06](#), Chapter 16, [ASHRAE-04](#), [ASHRAE-03](#), Chapter 32 and [SMACNA 1481](#).

The following types of [ASHRAE-07](#) [ASHRAE-06](#), Chapter 16, [ASHRAE-04](#) [ASHRAE-03](#), Chapter 32 and [SMACNA 1481](#) transverse joints shall be used:

Welded flange joint [with] [without] angle

Companion angle flanged joint

The following types of longitudinal seams shall be used:

Approved lock seams, back brazed, or continuously brazed seams for ducts with largest dimension up to [1800 millimeter](#) [72 inches](#)

Continuously welded or brazed seams for ducts with largest dimension greater than [1800 millimeter](#) [72 inches](#)

Sheet metal minimum thickness, transverse reinforcement between joints, and companion angle joints of ducts with longest side greater than [2550 millimeter](#) [96 inches](#) shall be in accordance with the following:

LONGEST SIDE (mm)	SHEET METAL THICKNESS ALL SIDES	COMPANION ANGLE (mm)	REINFORCEMENT ANGLES INCHES, 600 (mm) ON CENTER MAXIMUM (BACK TO BACK)
2450 to 2750	1.6	50 by 50 by 3, two tie rods along angle	Two 50 by 50 by 3, two tie rods along angle
2451 to 3350	1.6	50 by 50 by 5, two tie rods along angle	Two 50 by 50 by 5, two tie rods along angle
3351 and longer	2.0	65 by 65 by 5, with tie rods every 600 mm	Two 65 by 65 by 5, with tie rods every 600 mm
LONGEST SIDE INCHES	SHEET METAL GAGE ALL SIDES	COMPANION ANGLE INCHES	REINFORCEMENT ANGLES INCHES, 24 INCHES ON CENTER MAXIMUM (BACK TO BACK)
97 to 108	16	2 by 2 by 1/8, two tie rods along angle	*Two 2 by 2 by 1/8, two tie rods along angle
109 to 132	16	2 by 2 by 3/16, two tie rods along angle	*Two 2 by 2 by 3/16, two tie rods along angle
133 and longer	14	2-1/2 by 2-1/2 by 3/16, with tie rods every 24 inches	*Two 2-1/2 by 2-1/2 by 3/16, with tie rods every 24 inches

3.3.2 Round Sheet Metal Ducts

3.3.2.1 Duct Gages, Joints, and Reinforcement

Sheet metal minimum thickness, joints, and reinforcement between joints shall be in accordance with [ASHRAE-07](#) [ASHRAE-06](#), Chapter 16, [ASHRAE-04](#), [ASHRAE-03](#), Chapter 32 and [SMACNA 1481](#).

Longitudinal duct joint shall be manufactured by machine, with spiral lockseams to and including [1500 millimeter](#) [60 inch](#) diameters, and to dimensional tolerances compatible with fittings provided.

Ducts shall have supplemental girth angle supports, riveted with [solid rivets [150 millimeter](#) [6 inches](#) on center] [tack welded] [brazed] to duct. Girth angles shall be located as follows:

<u>DIAMETER, MILLIMETER</u>	<u>REINFORCEMENT-MAXIMUM SPACING, MILLIMETER</u>
625 to 915	32 by 32, 3.2 thick, 1825 millimeter on center
916 to 1270	32 by 32, 3.2 thick, 1525 millimeter on center
1271 to 1525	38 by 38, 3.2 thick, 1220 millimeter on center
<u>DIAMETER, INCHES</u>	<u>REINFORCEMENT-MAXIMUM SPACING, INCHES</u>
25 to 36	1-1/4 by 1-1/4, 1/8 thick, 72 inches on center
37 to 50	1-1/4 by 1-1/4, 1/8 thick, 60 inches on center
51 to 60	1-1/2 by 1-1/2, 1/8 thick, 48 inches on center

Draw band girth joints are not acceptable.

Slip joints shall be made up by coating the male fitting with elastomer sealing materials, exercising care to prevent mastic from entering fitting bore, leaving only a thin annular mastic line exposed internally. Sheet metal screws shall be used to make assembly rigid, not less than four screws per joint, maximum spacing 150 millimeter 6 inches. Pop rivets shall not be used. All joints shall be taped and heat sealed.

Bolt heads and nuts shall be hex-shaped, M8 5/16 inch diameter for ducts up to 1270 millimeter 50 inch diameter, and M10 3/8 inch diameter for 1271 millimeter 51 inch diameter ducts and larger.

Flanges shall be [continuously welded] [brazed] to duct on outside of duct and intermittently welded with 25 millimeter 1 inch welds every 100 millimeter 4 inches on inside joint face. Excess filler metal shall be removed from inside face. Galvanized areas that have been damaged by welding shall be protected with manufacturer's standard corrosion-resistant coating.

3.3.2.2 Duct Transitions

**NOTE: Rectangular duct with transitions specified
below should be used wherever building construction
or equipment are limiting factors.**

[Where the shape of a duct changes, the angle of the side of the transition piece shall not exceed 15 degrees from the straight run of duct connected thereto.]

Where equipment is installed in ductwork, the angle of the side of the transition piece from the straight run of duct connected thereto shall not exceed 15 degrees on the upstream side of the equipment and 22-1/2 degrees on the downstream side of the equipment.

3.3.3 Round, High Pressure, Sheet Metal Duct Installation

3.3.3.1 Joints

An inner coupling shall be provided to align the inner lining to maintain good airflow conditions equivalent to standard round high-pressure duct joints. Butt joints are not suitable for the inner liner. This alignment shall be accomplished by [extending the liner of the fitting for slip joint into the pipe] [by the use of a double concentric coupling with the two couplings held by spacers for rigidity and wall spacing]. For ducts over 860 millimeter 34 inches inside diameter, a separate coupling for inner alignment, with the pressure shells joined by angle-ring flanged connections, shall be provided.

3.3.3.2 Insulation Ends

At the end of an uninsulated section or run where internally insulated duct connects to uninsulated spiral duct, fitting, fire damper or flexible duct, an insulation end-fitting shall be installed to bring the outer pressure shell down to nominal size.

3.3.4 Transverse Reinforcement Joints

Transverse reinforcements shall be [riveted with solid rivets to duct sides 150 millimeter 6 inches on center] [spot welded 100 millimeter 4 inches on center]. Transverse reinforcement shall be welded at [all corners] [ends] to form continuous frames.

3.3.5 Joint Gaskets

Flanged joints shall be gasketed with chloroprene full-face gaskets 3.2 millimeter 1/8 inch thick, Shore A 40 durometer hardness. Gaskets shall be one piece, [vulcanized] [dovetailed] at joints.

3.3.6 Radius Elbows

Elbow proportions and radius elbows shall be fabricated in accordance with ASHRAE-07 ASHRAE-06, Chapter 16, ASHRAE-04 ASHRAE-03, Chapter 32 and SMACNA 1481.

3.3.7 Plenum Connections

Round duct connections shall be welded joint bellmouth type.

Rectangular duct connections shall be bellmouth type, constructed in accordance with ASHRAE-07ASHRAE-06, Chapter 16, ASHRAE-03 ASHRAE-04, Chapter 32 and SMACNA 1481.

3.3.8 Access Openings

Access panels shall be installed in ductwork adjacent to fire dampers.

Minimum size of access opening shall be 300 by 450 millimeter 12 by 18 inches, unless precluded by duct dimension.

Access openings shall be framed by welded and ground miter joint, 4 millimeter 1/8 inch thick [strap steel] [angle iron], with [7] [10] millimeter [1/4] [3/8] inch studs welded to frame. Cover plate shall be

not less than [1.6 millimeter 16-gage, reinforced as necessary for larger sizes] [constructed of 2.8 millimeter 12-gage metal].

In lieu of access doors, readily accessible flanged duct sections may be provided upon approval. Stable hanger supports shall be provided for disconnected duct termini.

3.3.9 Duct Supports

NOTE: Areas of seismic activity require seismically braced ducts per SMACNA.

Duct support shall be installed in accordance with ASHRAE-07 ASHRAE-06, Chapter 16, ASHRAE-04 ASHRAE-03, Chapter 32 and SMACNA 1481. Duct hangers shall meet the minimum size specified in ASHRAE-07 ASHRAE-06, Chapter 16, ASHRAE-04 ASHRAE-03, Chapter 32 and SMACNA 1481. Two hangers shall be provided where necessary to eliminate sway. Support attachment to duct surfaces, shall be by [solid rivet] [bolt] [welding] 100 millimeter 4 inches on center.

NOTE: Delete following paragraph if double-wall ducts are not required.

[Round, double-wall duct supports shall be as recommended by the manufacturer except that minimum hanger ring and strap size shall be 40 by 4 millimeter 1-1/2 inches by 1/8 inch.]

Selection of hanging system shall be at the Contractor's option, and shall take into account the location and precedence of work under other sections, interferences of various piping and electrical conduit, equipment, building configuration, structural and safety factor requirements, vibration, and imposed loads under normal and abnormal service conditions. Support sizes, configurations, and spacings are given to show the minimal type of supporting components required. If installed loads are excessive for the specified hanger spacing, hangers, and accessories [heavier-duty components shall be provided] [hanger spacing shall be reduced]. After system startup, any duct support device which, due to length, configuration, or size, vibrates or causes possible failure of a member, shall be replaced or the condition shall otherwise be alleviated. Special care shall be exercised to preclude cascade-type failures.

Hanger rods, angles, and straps shall be attached to beam clamps. Concrete inserts, masonry anchors, and fasteners shall be approved for the application.

NOTE: The following devices are an acceptable fastener in office buildings where unusual conditions do not occur.

Hardened high-carbon spring-steel fasteners fitted onto beams and miscellaneous structural steel are acceptable upon prior approval of each proposed application and upon field demonstration of conformance to specification requirements. Fasteners shall be made from steel conforming

to AISI Type [1055] [1070], treated and finished in conformance with SAE AMS 2480, Type Z (zinc phosphate base), Class 2 (supplementary treatment). A 72-hour load-carrying capacity shall be verified by a certified independent laboratory.

Hanger spacing shall provide a 20-to-1 safety factor for supported load.

Maximum load supported by any two fasteners shall be 45 kilogram 100 pounds.

Friction rod assemblies are not acceptable.

[Where support from metal deck systems is involved, support requirements shall be coordinated with installation of metal deck.]

Ductwork and equipment shall not be hung from roof deck, piping, or other ducts or equipment. Maximum span between any two points shall be 3000 millimeter 10 feet, with lesser spans as required by duct assemblies, interferences, and permitted loads imposed.

There shall be not less than one set of hangers for each point of support. Hangers shall be installed on both sides of all duct turns, branch fittings, and transitions.

Hangers shall be sufficiently cross braced to eliminate sway vertically and laterally.

Rectangular ducts up to 900 millimeter 36 inches shall be supported by strap-type hangers attached at not less than three places to not less than two duct surfaces in different planes.

Perforated strap hangers are not acceptable.

Rectangular ducting, 900 millimeter 36 inches and larger, shall be supported by trapeze hangers. Ducts situated in unconditioned areas and required to have insulation with a vapor-sealed facing shall be supported on trapeze hangers. Hangers shall be spaced far enough out from the side of the duct to permit the duct insulation to be placed on the duct inside the trapeze. Duct hangers shall not penetrate the vapor-sealed facing.

Where trapeze hangers are used, the bottom of the duct shall be supported on angles sized as follows:

<u>WIDTH OF DUCT, MILLIMETER</u>	<u>MINIMUM BOTTOM ANGLE SIZE, MILLIMETER</u>
760 and smaller	32 by 32 by 3.2
761 to 1200	38 by 38 by 3.2
1201 to 1830	38 by 38 by 4.8
1831 to 2440	50 by 50 by 6.4
2441 and wider	75 by 75 by 6.4
<u>WIDTH OF DUCT, INCHES</u>	<u>MINIMUM BOTTOM ANGLE SIZE, INCHES</u>
30 and smaller	1-1/4 by 1-1/4 by 1/8
31 to 48	1-1/2 by 1-1/2 by 1/8

<u>WIDTH OF DUCT, INCHES</u>	<u>MINIMUM BOTTOM ANGLE SIZE, INCHES</u>
49 to 72	1-1/2 by 1-1/2 by 3/16
73 to 96	2 by 2 by 1/4
97 and wider	3 by 3 by 1/4

Where ductwork system contains heavy equipment, excluding air-diffusion devices and single-leaf dampers, such equipment shall be hung independently of the ductwork by means of rods or angles of sizes adequate to support the load.

Ducting, when supported from roof purlins, shall not be supported at points greater than one-sixth of the purlin span from the roof truss. Load per hanger shall not exceed 875 kilogram 400 pounds when support is from a single purlin or 1750 kilogram 800 pounds when hanger load is applied halfway between purlins by means of auxiliary support steel provided under this section. When support is not halfway between purlins, the allowable hanger load shall be the product of 400 times the inverse ratio of the longest distance to purlin-to-purlin spacing.

When the hanger load exceeds the above limits, reinforcing of purlin(s) or additional support beam(s) shall be provided. When an additional beam is used, the beam shall bear on the top chord of the roof trusses, and bearing shall be over gusset plates of top chord. Beam shall be stabilized by connection to roof purlin along bottom flange.

Purlins used for supporting fire-protection sprinkler mains, electrical lighting fixtures, electrical power ducts, or cable trays shall be considered fully loaded, and supplemental reinforcing or auxiliary support steel shall be provided for these purlins.

NOTE: When vibration isolation is required, retain applicable portions of the following two paragraphs.

[Duct supports shall be vibration isolated from structure at points indicated. Refer to Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.]

[Vibration isolators shall be provided in discharge ducting system for a distance not less than 15 meter 50 feet beyond the air handling unit. Deflection of duct and equipment mountings shall be coordinated.]

3.3.10 Flexible Connectors for Steel Metal

Air-handling equipment, ducts crossing building expansion joints, and fan inlets and outlets shall be connected to upstream and downstream components by treated woven-cloth connectors.

Connectors shall be installed only after system fans are operative and all vibration isolation mountings have been adjusted. When system fans are operating, connectors shall be free of wrinkles caused by misalignment or fan reaction. Width of surface shall be curvilinear.

3.3.11 Insulation Protection Angles

Galvanized 1 millimeter thick 20-gage sheet, formed into an angle with a 50 millimeter 2 inch exposed long leg with a 10 millimeter 3/8 inch stiffening break at outer edge, and with a variable concealed leg, depending upon insulation thickness, shall be provided.

Angles shall be installed over all insulation edges terminating by butting against a wall, floor foundation, frame, and similar construction. Angles shall be fastened in place with blind rivets through the protection angle, insulation, and sheet metal duct or plenum. Angles shall be installed after final insulation covering has been applied.

3.3.12 Duct Probe Access

Holes shall be provided with neat patches, threaded plugs, or threaded or twist-on caps for air-balancing pitot tube access. Extended-neck fittings shall be provided where probe access area is insulated.

3.3.13 Openings in Roofs and Walls

Building openings are fixed and equipment shall be provided to suit.

3.4 FIELD QUALITY CONTROL

3.4.1 Fire Damper Tests

[Operational tests shall be performed on each fire damper in the presence of the Contracting Officer by energizing fusible link with localized heat. New links shall be provided and installed after successful testing.]

3.4.2 Ductwork Leakage Tests

Contractor shall conduct complete leakage test of new ductwork in accordance with Section 23 05 93.00 40 TESTING, ADJUSTING, AND BALANCING FOR HVAC SYSTEMS. Tests shall be performed prior to installing ductwork insulation.

NOTE: Delete the following paragraph and title if
inspections are not required.

3.4.3 Inspection

[Ductwork shall be inspected in accordance with SMACNA 1741.]

3.5 DUCTWORK CLEANING PROVISIONS

Open ducting shall be protected from construction dust and debris in a manner approved by the Contracting Officer. Dirty assembled ducting shall be cleaned by subjecting all main and branch interior surfaces to airstreams moving at velocities two times specified working velocities, at static pressures within maximum ratings. This may be accomplished by: filter-equipped portable blowers which remain the Contractor's property; wheel-mounted, compressed-air operated perimeter lances which direct the compressed air and which are pulled in the direction of normal airflow; and other means approved by the Contracting Officer. Compressed air used for cleaning ducting shall be water- and oil- free. After construction is

complete, and prior to acceptance of the work, construction dust and debris shall be removed from exterior surfaces. [SMACNA 1741.]

3.6 OPERATION AND MAINTENANCE

Contractor shall submit [6] [_____] copies of the [Operation and Maintenance Manuals](#) 30 calendar days prior to testing the medium/high pressure ductwork systems. Data shall be updated and resubmitted for final approval no later than 30 calendar days prior to contract completion.

-- End of Section --