

AIR DIFFUSION COUNCIL
Manufacturers of Flexible Air Duct

ADC AIR DIFFUSION COUNCIL

Flexible Duct Performance & Installation Standards

Fifth Edition



ADC AIR DIFFUSION COUNCIL, SCHAUMBURG, ILLINOIS



**Flexible Duct
Performance and
Installation Standards**

Fifth Edition
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Air Diffusion Council

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Mission Statement of The Air Diffusion Council

The purpose for which the Air Diffusion Council was formed, as stated in its Certification of Incorporation, is to promote and further the interests of manufacturers of air distribution equipment, more specifically, flexible air ducts and related products, and the interests of the general public in the areas of safety, quality, efficiency and energy conservation, and to this end, develop programs approved and supported by the membership that legally promote and further these interests, such as:

- *To encourage, assist and support the maintenance and development of credible and effective industry standards for the installation, use and performance of flexible duct products; to promote the use of those standards by various code bodies, government agencies; architects, engineers, heating and air conditioning contractors, etc. so that the best interests of the public may be served.*
- *To collect and disseminate lawful information of value to members of the Council, the general public and others and to act as a clearing house for all such information, as well as providing a means by which the interests of the individual members of the Council can be protected, defended, supported more vigorously and effectively in legal association with others who share those interests.*

ADC Bylaws, Article 1, Section 2 (1996)

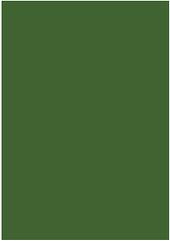


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Foreword

This standard was developed by the Air Diffusion Council. It is intended for use by the HVAC industry, including manufacturers, designers, installers, contractors, code bodies, inspectors and end users.

The Flexible Duct Performance and Installation Standard is to be used as a comprehensive document in evaluating, selecting, specifying and installing flexible duct in heating, air conditioning and ventilating systems.

Authorities considering adoption and/or reference of this standard should review all federal, state, local and other applicable regulations. The Air Diffusion Council assumes

no responsibility nor accepts any liability for the application or techniques contained in the standard.

This standard is subject to review and revision as the art of the industry advances or experience in the industry may dictate.



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References

ACCA Manual D - Residential Duct Design

ACCA Manual Q - Commercial Low Velocity, Low Pressure, Duct Design

ADC Standard FD 72-R1 - Flexible Duct Test Code

ASHRAE 120 - Method of Testing to Determine Flow Resistance of HVAC Ducts and Fittings

ASHRAE Handbook - Fundamentals and Equipment Volumes

ASTM E84 - Test for Surface Burning Characteristics of Building Materials

ASTM E96 - Water Vapor Transmission of Materials in Sheet Form

ASTM C167 - Thickness and Density of Blanket or Batt Thermal Insulations

ASTM C177 - Thermal Conductivity of Materials by Means of the Guarded Hot Plate

ASTM E477 - Duct Liner Materials and Prefabricated Silencers for Acoustical and Airflow Performance

ASTM C518 - Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter

NFPA Standard 90A - Installation of Air Conditioning and Ventilating Systems

NFPA Standard 90B - Warm Air Heating and Air Conditioning Systems

NFPA Standard 255 - Method of Test of Surface Burning Characteristics of Building Materials

NAIMA - Fibrous Glass Duct Construction Standards

SMACNA - HVAC Duct Construction Standards, Metal and Flexible

UL Heating, Cooling, Ventilating and Cooking Equipment Directory

UL Standard 181 - Factory-Made Air Ducts and Air Connectors

UL Standard 181B - Closure Systems for Use With Flexible Air Ducts and Air Connectors

UL Standard 723 - Tests for Surface Burning Characteristics of Building Materials

Glossary of Terminology

Air Barrier The membrane of the flexible duct which actually contains the air volume.

Air Connector A category of flexible duct not meeting the requirements of an Air Duct per UL 181 Standard (not tested for flame penetration, puncture and impact) and having limitations on use, length and location as defined by NFPA 90A and 90B. Air Connectors are identified by a “round shape” listing label of the listing agency.

Air Duct A category of flexible duct tested and classified as to the Surface Burning Characteristics in accordance with the UL 181 Standard and identified by a “rectangular shape” listing label of the listing agency.

Authority Having Jurisdiction The organization, office or individual responsible for and having final approval concerning use of flexible duct and its installation.

Classification For purposes of this standard, a method of identifying, marking and specifying flexible duct as related to listing category, physical style, positive pressure class and velocity type.

Equivalent Length Additional length added to the actual duct length in duct sizing calculations to account for the frictional resistance of fittings, bends, etc (see Total Equivalent Length).

Excess Length The difference between the fully stretched cut length and the measured, straight-line, entrance-to-exit span length.

Flexible Duct A preformed, flexible, tubular passage for supply, return and exhaust air in HVAC systems. For purposes of this document, the terms designated Air Duct and Air Connector are used interchangeably, however not in their intended use and application.

Friction Loss (Bends) The static pressure loss in bends of flexible duct, expressed as a dimensionless coefficient (C_0) at a specified bend radius ratio. C_0 is a dimensionless coefficient which represents the ratio of the total pressure loss to the dynamic pressure in terms of velocity pressure.

Friction Loss (Straight) The static pressure loss in a straight run of flexible duct, expressed in inches of water gauge (in. w.g.) per 100 feet [Pa/m].

Inner Core/Liner That portion of insulated flexible duct which determines the internal dimensions and inner physical form.

Installation Instructions A manufacturer's printed instructions in accordance with the terms of their listing which advises the method and materials to install the flexible duct.

Leakage The time rate of air volume loss expressed in cubic feet per minute (cfm) [L/s].

Listed A published list by a recognized approving agency acceptable to the authority having jurisdiction stating that the flexible duct, tape, mastic, and clamp have been tested to and comply with the applicable Standard UL 181/UL 181B and maintains periodic inspection to assure production of the listed products

are in accordance with the listing.

Listing Mark/Label A printing, tag or other marking device of the listing agency permanently and prominently affixed to the listed product that certifies compliance to the applicable Standard UL 181/UL 181B and contains recommendations relating to installation and maximum physical conditions of use.

Lot A collection of units of a product of a single category, style, class and type manufactured under essentially the same conditions and from which a sample is to be drawn and inspected for conformance to specification.

Permeance The time rate of water vapor transmission through the vapor barrier expressed in U.S. perms [ng/(s·m²·Pa)].

Pressure The positive or negative static pressure expressed in inches of water gauge (in. w.g.) [Pa].

Radiated Noise The sound power level transmitted through the duct wall, expressed in decibels (dB).

Sag The distance deviation, expressed in inches per lineal foot [mm/m] of flexible duct, from a horizontal or inclined plane between suspension points on installed flexible duct.

Snaking Unnecessary directional change in any plane (horizontal, vertical, inclined) that produces excess pressure drop.

Sound Attenuation (Insertion Loss) The extent to which sound power level is reduced (attenuated) as it travels through a flexible duct, expressed in decibels (dB).

Sound Generation The sound power level which is generated by the movement of air through a flexible duct, expressed in decibels (dB).

Thermal Conductivity (k) The time rate of heat flow through unit thickness of an infinite slab of homogeneous material in a direction perpendicular to the surface, induced by unit temperature difference. Expressed in BTU-in./hr.-ft.²-°F [W/(m²-C)].

Thermal Resistance (R) The mean temperature difference, at equilibrium, between two defined surfaces of material or a construction that induces a unit heat flow rate through unit area. Expressed in hr.-ft.²-°F/BTU [(m²-°C)/W].

Total Equivalent Length The sum of actual duct length and the equivalent length of fittings, bends, etc (see Equivalent Length).

Ultraviolet (UV) Light Invisible radiation in the electromagnetic spectrum lying between visible light (380nm) and x-rays (100nm). UV is arbitrarily categorized into short, medium and long wavelength bands: UV-A (315-380nm), UV-B (280-315nm) and UV-C (100-280nm). UV radiation occurs naturally in sunlight or can be artificially generated.

Vapor Barrier/Retarder The outer membrane of an insulated flexible duct.

Velocity The average time rate of air flow expressed in feet per minute (fpm) [m/s].

Introduction

1.1 Purpose

This standard sets forth specific methods of classifying, testing and marking flexible air ducts for indoor comfort heating, ventilating and air conditioning applications. This standard sets forth instructions for properly installing flexible ducts in air distribution systems.

1.2 Scope

This standard includes requirements for both insulated and non-insulated flexible ducts. No attempt is made in this standard to designate a specific material or construction.

Special considerations not covered by this standard may be required when flexible ducts are used in:

- a. Industrial applications; i.e. particulate conveying, corrosive atmospheres, excessive temperatures, etc.
- b. Outdoor applications; i.e. continuous exposure to direct sunlight, weathering elements etc.

Ducts shall be listed in conformance to NFPA Standards 90A and 90B.

- a. They shall be tested in accordance with Underwriters Laboratories Standard for Factory-Made Air Ducts and Air Connectors, UL 181.
- b. Such ducts shall be installed in accordance with the conditions of their listing.

1.3 Units of Measurement

This standard is written in inch-pound (I-P) units followed by SI units in brackets []. Metric symbols and units are consistent with SI policy, however some deviations have been taken in conversion values and rules-of-rounding. Examples of some deviations are:

Diameter conversions are based on 25 mm/in. dia.

A 12 in. duct diameter converts to 300 mm.

Length conversions are rounded to the nearest 0.1 m.

A 14 ft. duct length converts to 4.3 m.

Linear dimensions are rounded to the nearest 1 mm.

A 1½ in. duct strap converts to 38 mm.

Pressure conversions use 250 Pa/inch w.g.

A pressure of 6 in. w.g. converts to 1500 Pa.

Note: When more precise conversions are required, follow ASHRAE Policy on SI Units.

1.4 Classification

Flexible ducts shall be categorized as either Air Ducts or Air Connectors in accordance with testing and listing requirements in Table 1. Flexible ducts will appear in one of the following styles (see Figures 1 - 5):

NM-IL	Non Metallic, Insulated lined with nonporous inner core
NM-UN	Non Metallic, Uninsulated
M-I	Metallic, Insulated
M-UN	Metallic, Uninsulated
NM-IP	Non Metallic, Insulated with porous inner core

Flexible ducts, as part of this standard and for the purpose of application use only, shall be one of the following pressure classes and velocity types.

Positive Pressure Class	Velocity Type
Pressure (Up to and including)	Velocity (Up to and including)
1/2 in. w.g. [125 Pa]	1000 fpm [5.1 m/s]
1 in. w.g. [250 Pa]	2500 fpm [12.7 m/s]
2 in. w.g. [500 Pa]	4000 fpm [20.3 m/s]
3 in. w.g. [750 Pa]	Over 4000 fpm [20.3 m/s]
4 in. w.g. [1000 Pa]	
6 in. w.g. [1500 Pa]	
10 in. w.g. [2500 Pa]	

Characteristics of Flexible Duct

2.1 Description

Flexible ducts usually are packaged in compressed form in a variety of lengths with plain ends or as assemblies with special end fittings attached to either or both ends. Diameters generally range from 2" [50 mm] through 12" [300 mm] in 1 in. [25 mm] increments and 14" [350 mm] through 22" [560 mm] in 2 in. [50 mm] increments. Most flexible ducts are slightly over-sized in diameter to fit over standard sheet metal fittings (see "Dimensions and Tolerances" in Section 3.5).

2.2 Typical Styles

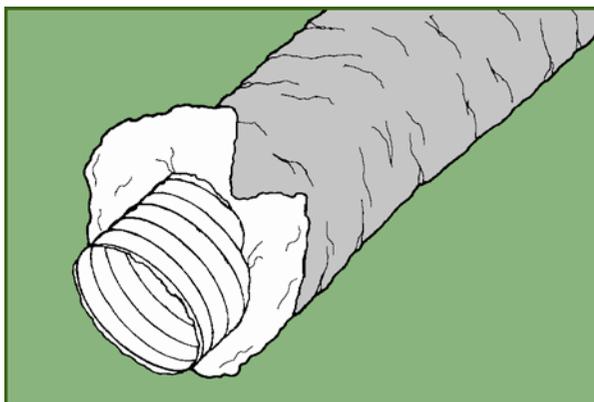


Figure 1 Style NM-IL - Nonmetallic, Insulated, Lined (Non porous Inner Core)

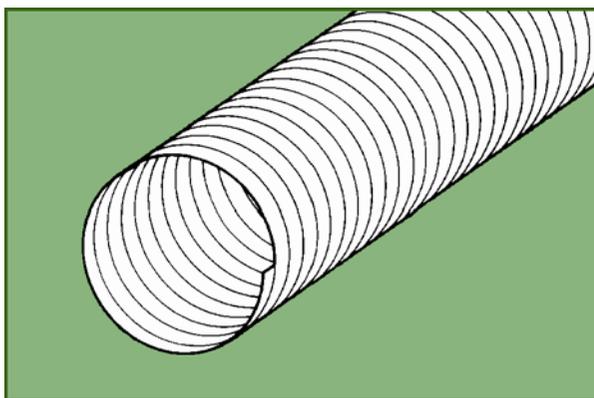


Figure 2 Style NM-UN Nonmetallic, Uninsulated

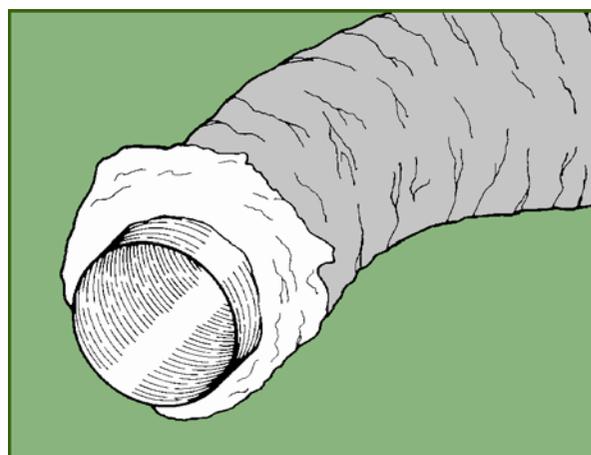


Figure 3 Style M-I - Metallic, Insulated

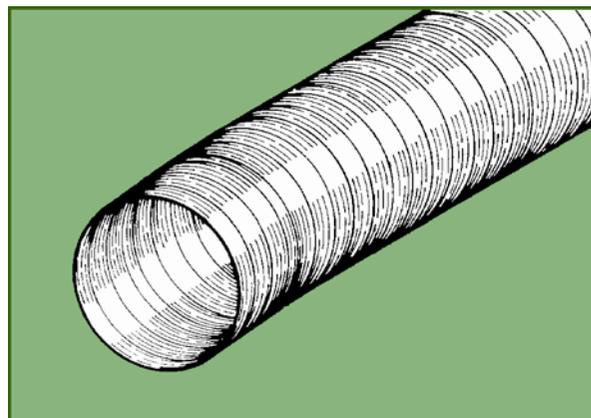


Figure 4 Style M-UN - Metallic, Uninsulated

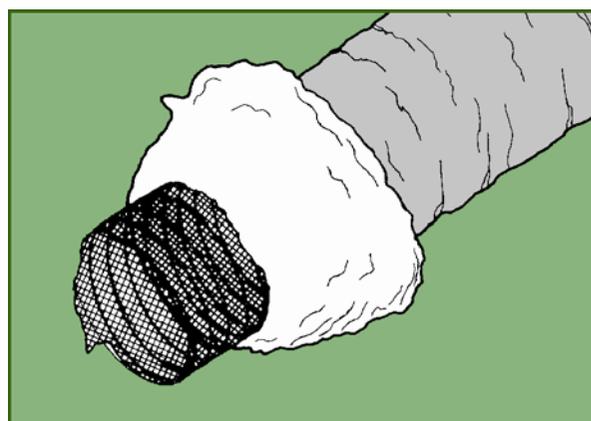


Figure 5 Style NM-IP - Nonmetallic Insulated, Perforated (Porous Inner Core)

Testing, Listing, Reporting and Certifying

3.1 General Instructions

Flexible ducts conforming to this standard shall be tested, listed, reported and certified as applicable, in accordance with the requirements of this standard. Testing requirements by category are shown in Table 1.

3.2 Listing Requirements

Factory made air ducts and air connectors shall be tested and listed in accordance with Underwriters Laboratories Standard for Factory-Made Air Ducts and Air Connectors, UL 181. The UL Heating, Cooling, Ventilating and Cooking Equipment Directory publishes such listings.

Table 1

Test	Air Ducts	Air Connectors
Surface Burning Characteristics ¹	x	x
Flame Penetration	x	-
Burning	x	x
Corrosion ^a	x	x
Mold Growth and Humidity	x	x
Temperature	x	x
Puncture	x	-
Static Load	x ^b	x ^b
Impact	x	-
Erosion ²	x	x
Pressure ²	x	x
Collapse ²	x	x
Tension	x	x
Torsion	x	x
Bending	x	x
Leakage	x	x
Listing Label Shape	Rectangular	Round

Key to Table 1

- X** Test applicable
- Test not applicable
- a** Applicable to parts of metals not inherently corrosion resistant.
- b** Test applicable for flexible air ducts and air connectors that incorporate vapor barriers supported by grommets or other means of field support.

Footnote 1

Tests for surface burning characteristics are to be conducted as specified for Surface Burning Characteristics of Building Materials, UL 723 (ASTM E84, NFPA 255).

Class 0 Material: Shall have surface burning characteristics of zero (flame spread/smoke developed).

Class 1 Material: Shall have flame spread rating of not over 25 without evidence of continued progressive combustion and a smoke-developed rating of not over 50.

Footnote 2

These three tests, Pressure, Erosion and Collapse, are run at 2.5 times the manufacturer's stated rating for that property. For the erosion test, the variable is velocity; for the pressure test the variable is positive pressure; for the collapse test, the variable is negative pressure.

Testing, Listing, Reporting and Certifying . . . continued

3.3 Performance Values

Table 2 lists the required tests and units of measurement and recommended values of minimum performance where applicable.

Table 2

For comparison purpose only. Not for design. For detailed design data, refer to manufacturer's product engineering data.

Property		Recommended Performance Value
Thermal Loss* All diameters	R: hr·ft ² ·°F/BTU [(m ² ·°C/W)]	Test - Section 3.4 - Thermal Performance 4.2 [0.74](minimum) @ 75°F [24°C] mean temperature
Friction Loss 12" [300 mm] diameter	Straight:(in.w.g. per 100 ft. [Pa/m] of duct @ 1000 fpm [5.1 m/s]) 90° bend loss coefficient (C _o) @ R/D = 2	Test - Section 3.4 - Friction Loss 0.3 [2.5] (maximum) 1.0 (maximum)
Acoustical (dB)	Sound Attenuation Sound Generation Radiated Noise	Test - Section 3.4 - Acoustical Performance Due to complexity of data, no recommended value of performance is stated. Refer to Manufacturer's Data.
Static Press./Temp 12" [300 mm] diameter	At Recommended Operating Positive Pressure (in. w.g.) [Pa]	Test - Section 3.4 - Static Press./Temp. Performance 140° F [60° C] Continuous 180° F [82° C] Intermittent
Leakage All diameters	cfm/in. (dia.)·ft. (length) [L/s/mm (dia.)·m (length)]	Test - Section 3.4 - Leakage (Duct Only) 0.03 [1.7 x 10 ⁻⁴]
Leakage All diameters	cu.ft./hr. [L/s]	Test - Section 3.4 - Leakage (Including Connections) 0.87 [1.1 x 10 ⁻⁵] D ² (maximum) where D is internal duct diameter in inches [mm].
Permeance* All diameters	U.S. Perms [ng/(s·m ² ·Pa)]	Test - Section 3.6 Water Vapor Transmission Rates of Vapor Barriers 1.0 [57.5] (maximum)

* Not applicable to uninsulated ducts.

Testing, Listing, Reporting and Certifying . . . continued

3.4 Performance Requirements

Thermal Performance. Thermal loss properties of insulated flexible duct shall be based on flat sections of insulation only at installed duct wall thickness and excluding any air film resistance.

The thermal resistance (R) shall be determined using the relationship: $R = th / k$.

Where: R = Thermal resistance (hr-ft² - °F/Btu)
[(m²·°C)/W] rounded to the nearest 0.1

th = duct insulation wall thickness (in.)
[mm] rounded to the nearest 1/16
inch [2 mm].

k = measured apparent thermal
conductivity (Btu-in/hr-ft² - °F)
[W/(m·°C)]

The insulation's thermal conductivity is measured according to ASTM C518 or ASTM C177 at 75°F [24° C] mean temperature. Installed insulation thickness is determined in the following manner (see note 1 and 2 below).

$$th = \frac{\left\{ \frac{\text{Jacket Layflat Width} \times 2}{3.14159} \right\} - \text{Nom. Core Dia.}}{2}$$

The jacket layflat width can be determined by circumferentially cutting the jacket, removing it from the duct, laying it on a flat surface and measuring the width to the nearest 1/16 inch [2 mm].

Note 1 The out-of-package insulation thickness measured in accordance with ASTM C167 shall be equal to or greater than the calculated installed duct insulation wall thickness.

Note 2 Actual internal core diameter shall be within the tolerances of +3/8, -0 in. [+9,-0 mm] of nominal core diameter.

Friction Loss. Friction loss shall be determined in accordance with the ADC Test Code FD 72-R1 or in accordance with ASHRAE 120. Friction loss for straight runs shall be presented in graphical form over the manufacturer's rated velocity range and size range. Friction loss in 90° bends shall be presented in graphical form at three different bend radii.

Straight Runs:

Friction loss - inches of water gauge per 100 feet [Pa/m] of duct, shall be plotted on the horizontal axis, and "Air volume - CFM [L/s]" on the vertical axis. For convenience of the user, corresponding velocities may also be plotted. For purposes of recommended performance values in Table 2, a 12" [300 mm] nominal internal duct size, tested at 1000 fpm [5.1 m/s] velocity shall be used.

90° Bends:

Friction loss coefficient (C_o) - dimensionless coefficient, shall be plotted on the vertical axis, and the internal duct diameter shall be plotted on the horizontal axis. Each R/D value tested shall be plotted. For purpose of recommended performance values for 12" [300 mm] nominal I.D. duct in Table 2, a loss coefficient of $R/D = 2$ shall be used.

The term C_o is a dimensionless coefficient which represents the ratio of the total pressure loss to the dynamic pressure in terms of velocity pressure.

Testing, Listing, Reporting and Certifying . . . continued

Acoustical Performance. When acoustical properties are claimed, the duct shall be tested in accordance with ASTM E477 and/or ADC Test Code FD 72-R1. Data shall be presented in the following form:

Attenuation:

Sound attenuation test data shall be reported by tabulation in either dB/lineal foot [dB/m] or as dB for specified length (such as dB/3 ft. [1.0 m] or dB/12 ft. [3.7 m]). In either case, the table of values shall show attenuation at center frequencies of 125, 250, 500, 1000, 2000, 4000 hertz. The table shall also indicate whether determinations were made with or without air flowing and the maximum velocity range to which data is applicable.

Because this data is not necessarily linear, the limits of linearity shall be stated. Notes shall accompany data explaining the limits of use. No additional attenuation may be claimed for lengths greater than the lengths tested.

Sound Generation:

Sound generation test data shall be reported for at least four different velocities selected from the following range of velocities (shall include maximum rated velocity): 400, 800, 1000, 1500, 2000, 2500, 3000, 4000 and 6000 fpm. [2.0, 4.1, 5.1, 7.6, 10.2, 12.7, 15.2, 20.3 and 30.5 m/s]

Sound generation test data shall be reported by tabulation in either dB/linear foot [dB/m] or dB for specified length tested. Tabulated data shall show sound generation at center frequencies of 125, 250, 500, 1000, 2000 and 4000 hertz.

Radiated Noise:

Radiated noise reduction shall be reported with 0 air flow and at one flow of 2500 fpm [12.7 m/s] velocity or the option of 4000 [20.3] or 6000 [30.5] fpm [m/s] velocity for each duct diameter tested

Radiated noise reduction shall be reported as dB/linear foot [db/m] or dB for a specified length at center frequencies of 125, 250, 500, 1000, 2000 and 4000 hertz.

Static Pressure/Temperature Performance. Flexible duct shall be tested under simultaneous temperature and pressure conditions in accordance with ADC Test Code FD 72-R1.

Test temperatures and times under this standard shall be:

Continuous Temperature/Time - 140° F [60° C] for 164 hours.

Intermittent Temperature/Time - 180° F [82° C] for 4 hours.

For purpose of recommended performance values in Table 2, a 12" [300 mm] nominal internal duct size shall be tested. In addition, the smallest and largest size of the diameter range shall be tested for comparative performance verification.

Leakage - Duct Only. Leakage shall be determined in accordance with ADC Test Code FD 72-R1. Duct leakage shall be reported as an average leakage rate of air volume loss per unit internal diameter per unit length (CFM/in.dia./ft.) [L/s/mm dia./m].

Leakage - Including Connections. Shall be determined in accordance with UL 181 requirements.

Testing, Listing, Reporting and Certifying . . . continued

3.5 Material Characteristics

There are specifications external to this standard based on specific properties of component materials. When required, data should be determined and reported in accordance with the following procedure.

Permeance. Water vapor permeance of the jacketing material is applicable only to insulated flexible duct. Permeance shall be tested and reported in accordance with Section 3.6 “Water Vapor Transmission Rates of Vapor Barriers.”

Dimensions and Tolerances. Dimensions and tolerances of flexible ducts shall be within the tolerance listed on the manufacturer’s data sheets. Length shall not be less than advertised nominal when measured fully extended in accordance with Section 3.6 “Length Measurement.”

Sampling. Unless otherwise stated in the purchase document, quality records maintained by the manufacturer will suffice in the relationship between the purchaser and manufacturer. If they mutually agree to accept lots on the basis of the quality control records, no further sampling is required.

3.6 Methods of Test

Water Vapor Transmission Rates of Vapor Barriers (Retarders). The water vapor transmission rate of vapor barriers shall be determined in accordance with ASTM E96, Procedure A. Specimens for test shall be selected in the following manner. A sample of flexible duct shall be selected from production material which has been stored in its standard package a minimum of twenty-four (24) hours. Specimens 12 in. x 12 in. [300 mm x 300 mm] shall be cut from each at the approximate center of the sample duct.

WVTR specimens will then be prepared and tested in accordance with procedures outlined in ASTM E96, Procedure A.

The permeance of the material shall be reported as the average of the three determinations tested. The results are to be reported in U.S. perms [$\text{ng}/(\text{s}\cdot\text{m}^2\cdot\text{Pa})$].

Length Measurement. A length of flexible duct which has been packaged in compressed form shall be measured with a tape after fully extending the duct. Measure while maintaining the tension.

For referee measurement: Apply an axial load of 25 lbs. [11.3 Kg], measured by a force gauge, to the product for one minute. Measure the length with the axial tension applied after the duct is fully extended.

3.7 Product Marking

Listing Mark and Label Information. All ducts shall be marked, labeled or printed at maximum intervals of 10 ft. [3.0 m] or fraction thereof. Labels shall contain at least the following information.

- a. Identifying mark of the listing agency
- b. Manufacturer's identification
- c. Maximum Positive and Negative pressure rating
- d. Maximum Rated Velocity
- e. R-Value (applicable to insulated ducts only)
- f. Classification of Surface Burning Characteristics (Class 0 or 1)
- g. Identification as either an Air Duct or Air Connector

Note 1 Air Connector identification shall further state "Not to be installed in lengths greater than 14 ft [4.3 m]."

Note 2 Air Duct labels shall be square or rectangular in shape; Air Connector labels shall be round in shape. Reference to listed installation instructions.

ADC Logo. A mark which is separate and distinct from the listing mark and label containing the following information and indicating compliance with this standard.



3.8 Product Certification

Upon request, the manufacturer shall certify that its product(s) conform to the requirements of this standard.

Seal of Certification. A mark separate and distinct from the ADC label. This seal signifies third-party verification to a specific performance requirement of this standard by an ADC "Recognized Testing Laboratory".



3.9 Product Packaging

Unless otherwise agreed or specified between the purchaser and the manufacturer, flexible duct shall be packed in the manufacturer's standard commercial containers.

Unless otherwise specified, each container shall be marked with the following information:

- a. Manufacturer or Brand Name
- b. Product designation product name (optional)
- c. Size (internal diameter)
- d. Nominal Length of duct section
- e. Number of sections per container
- f. Storage and/or stocking instructions (if any)
- g. Production date or date code of the manufacturer.

Each container shall contain the manufacturer's specific installation instruction. (Optionally, these instructions may be printed on the container.)

Installation Requirements

4.1 Code Reference

The “authority having jurisdiction” should be referenced to determine what law, ordinance or code shall apply in the use of flexible duct.

Ducts conforming to NFPA 90A or 90B shall meet the following requirements:

- a. Shall be tested in accordance with Sections 7 to 23 of Underwriters Laboratories Standard for Factory-Made Air Ducts and Air Connectors, UL 181.
- b. Shall be installed in accordance with the conditions of their listing.
- c. Shall be installed within the limitations of the applicable NFPA 90A or 90B Standard.

4.2 Installation Restrictions and Use Limitations

There are specific restrictions and limitations related to the use of flexible ducts. Some are due to NFPA Standards, model codes and various state/local codes. Others are due to end use performance where the product was not designed for that specific use. Some, but not all inclusive, are as follows:

- a. Shall not be used for vertical risers serving more than two stories in height.
- b. Shall not be used in systems with entering air temperature higher than 250°F[121°C].
- c. Shall be installed in accordance with the conditions of their listing.
- d. When installed in a fire-rated floor/roof ceiling assembly, ducts shall conform with the design of the tested fire-resistive assembly.
- e. Shall be interrupted at the immediate area of operation of electric, fossil fuel or solar energy collection heat sources to meet listed equipment clearances specified.

- f. Air Connectors (does not apply to Air Ducts) shall not be installed in lengths greater than 14 ft. [4.3 m] for any given run; shall not pass through any wall, partition or enclosure of a vertical shaft with a 1 hour or more fire resistive rating; shall not pass through floors.
- g. Shall not penetrate walls where fire dampers are required.
- h. Shall not be used outdoors unless specifically designed to withstand exposure to direct sunlight and the weathering elements.
- i. Shall not be used to vent appliances for cooking, heating and clothes drying unless approved and recommended by the appliance manufacturer.
- j. Shall not be installed in concrete, buried below grade or in contact with the ground.

4.3 General

The routing of flexible duct, the number of bends, the degrees in each bend, and the amount of sag or direction changes (snaking) allowed between support joints will have serious effects on system performance due to the increased resistance each introduces (See Fig 6 & 7). Use the minimum length of flexible duct to make connections (See Section 4.5). Excess length of flexible duct shall not be installed to allow for possible future relocations of air terminal devices.

Avoid installations where exposure to direct sunlight can occur, e.g. turbine vents, sky lights, canopy windows, etc. Prolonged exposure to sunlight will cause degradation of the vapor barrier. Direct exposure to UV light from a source lamp installed within the HVAC system will cause degradation of some inner core/liner materials.

Terminal devices shall be supported independently of the flexible duct.

Repair torn or damaged vapor barrier/jacket with duct tape listed and labeled to Standard UL 181B. If internal core is penetrated, replace flexible duct or treat as a connection.

4.4 Installation and Usage

Install ducts fully extended. Do not install in the compressed state or use excess length as this will noticeably increase friction losses. (Refer to Section 4.5 for more specific information regarding pressure loss and duct sizing.)

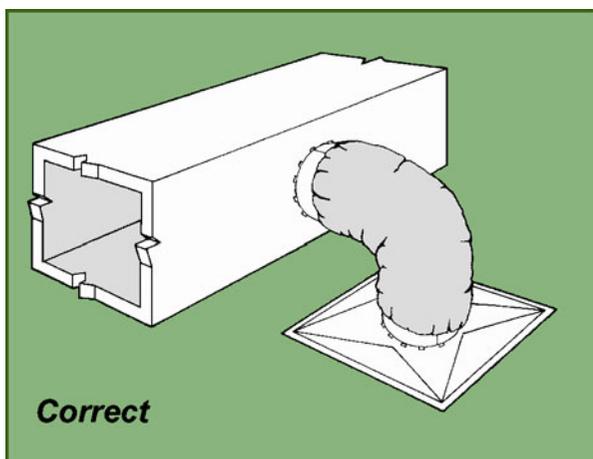


Figure 6 - Minimum duct length and bend radius reduces pressure drop and improves airflow.

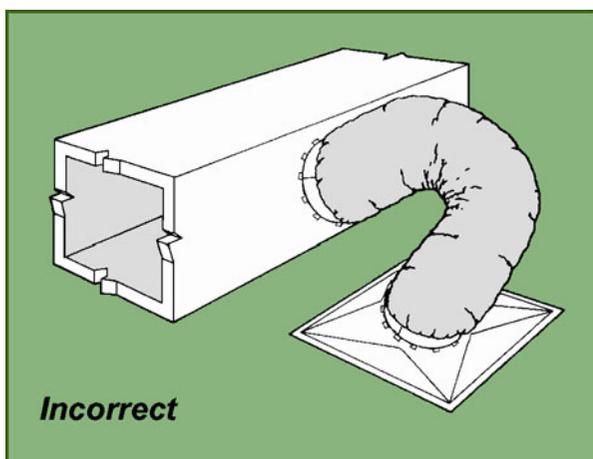


Figure 7 - Excess length and tight bend radius increases pressure drop and reduces airflow.

Do not bend ducts across a sharp corner of building materials such as joists or truss supports.

The bend radius at the center line of ducts shall be equal to or greater than one duct diameter (See Figures 8 and 11). Sharper bends increase pressure drop significantly and reduce airflow.

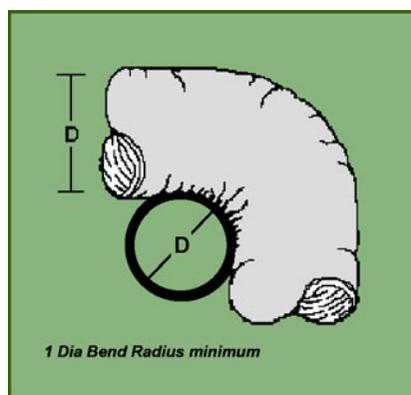


Figure 8 - Correct. Minimum 1 duct diameter bend radius reduces pressure drop and improves air flow.

Avoid incidental contact with metal fixtures, water lines, pipes, or conduits. Do not install near hot equipment (e.g. furnaces, boilers, steam pipes, etc.) that is above the recommended flexible duct use temperature.

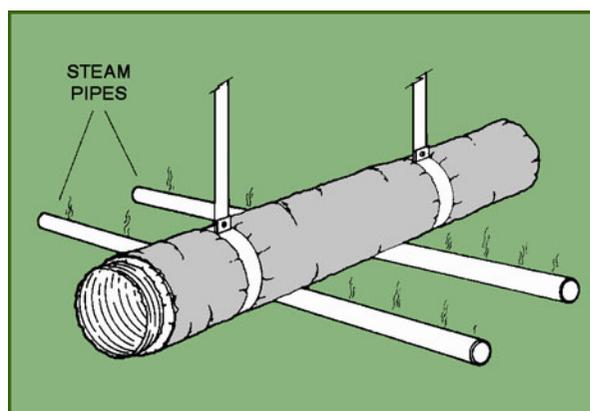


Figure 9 - Incorrect. Contact with steam pipes.

Installation Requirements . . . continued

4.5 Duct Sizing and Routing

The combined friction and dynamic pressure losses shall be taken into consideration to properly size any duct. Pressure losses caused by the roughness of the duct wall resisting air movement are known as friction losses. Pressure losses when air flow changes direction, as caused by bends or when air flows across other system components, are known as dynamic losses.

Key points to prevent undersizing or oversizing of flexible ducts and achieve the designed air delivery performance:

- a. Use a proven method of duct sizing, one that has taken into consideration both friction and dynamic losses.

Design the flexible duct system per the requirements of ACCA, Manual D (Residential) and Manual Q (Commercial).

Properly take into account duct length, bend losses, sagging or routing expectations, fitting losses, etc.

- b. Have a good understanding of and properly use the air friction chart.

Do not use data for round sheet metal duct.

Since all flexible ducts are not alike, use the flexible duct manufacturer's air friction loss data to size the ducts whenever possible.

If no data is available, use the generic flexible duct friction loss chart in ACCA Manual D.

- c. Use the minimum length of flexible duct needed to make the connections.

Install ducts extended to their fullest length without compression. Due to the helical configuration of flexible duct inner cores, excess longitudinal compression can dramatically affect the pressure drop.

If a flexible duct is not fully extended, the friction rate increases proportionally with the compression (See Fig. 10).

When a flexible duct is fully extended, it is said to have no more than 4% longitudinal compression and the published friction rate may be used for duct sizing calculations ($0 - 4\% = 1 \times \text{Friction Rate}$).

For 15% longitudinal compression the friction rate can increase by a factor of two ($15\% = 2 \times \text{Friction Rate}$).

For longitudinal compression of 30% the friction rate can increase as much as four times ($30\% = 4 \times \text{Friction Rate}$).

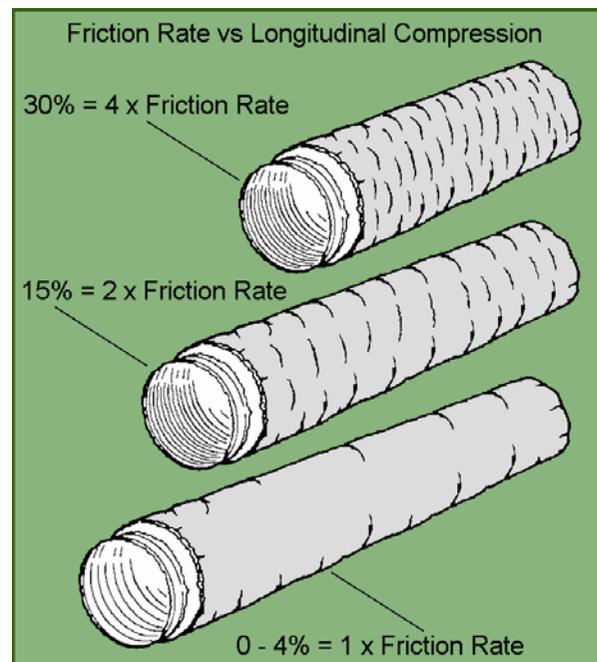


Figure 10 - Compressed duct (not fully extended) increases friction rate.

Installation Requirements . . . continued

- d. Keep bends greater than or equal to one (1) duct diameter bend radius.

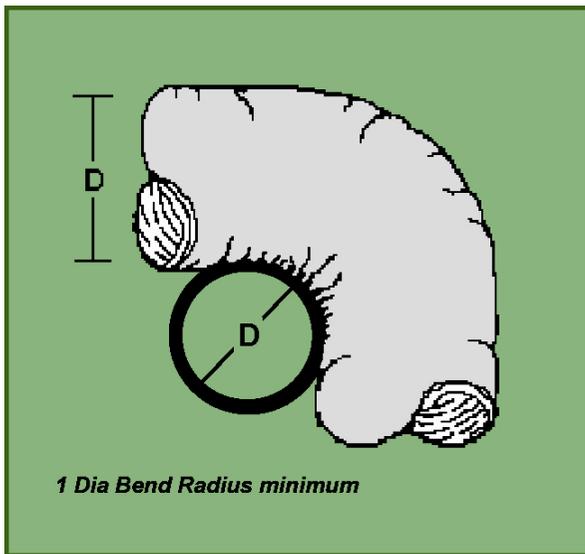


Figure 11

- e. Properly route and support the flexible duct runs.

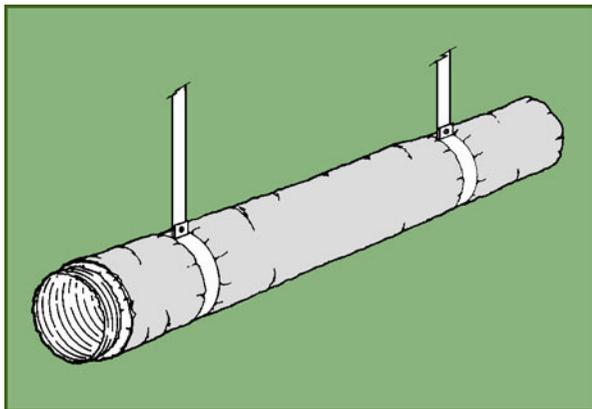


Figure 12

Care shall be taken to minimize sagging or snaking of the duct between supports and minimize pressure loss caused by excessive direction changes to the airflow.

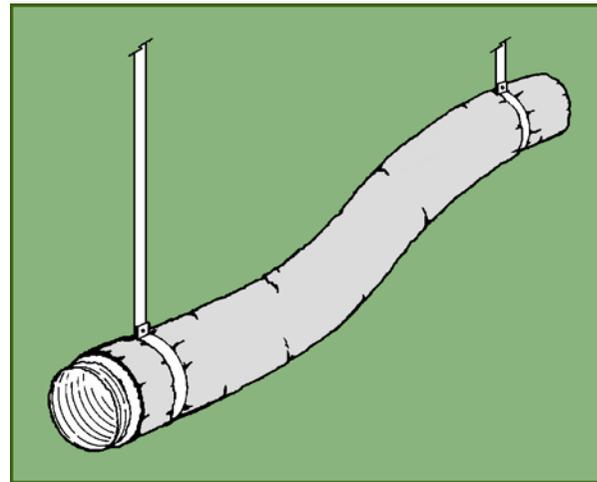


Figure 13

Ducts shall not be crimped against joist or truss members, pipes, wires, etc. as this increases pressure loss and reduces air flow.

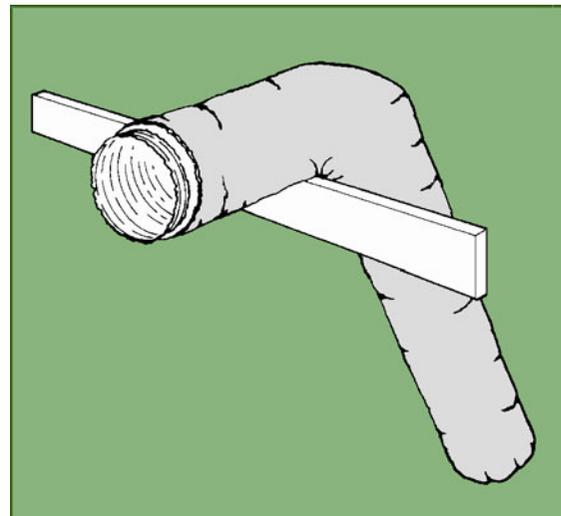


Figure 14

Installation Requirements . . . continued

- f. Properly account for bends in the duct runs.

A 90-degree bend has pressure drop equal to approximately twenty (20) lineal feet of flexible duct. So each 90-degree bend will add twenty (20) equivalent feet to the length used for sizing calculations.

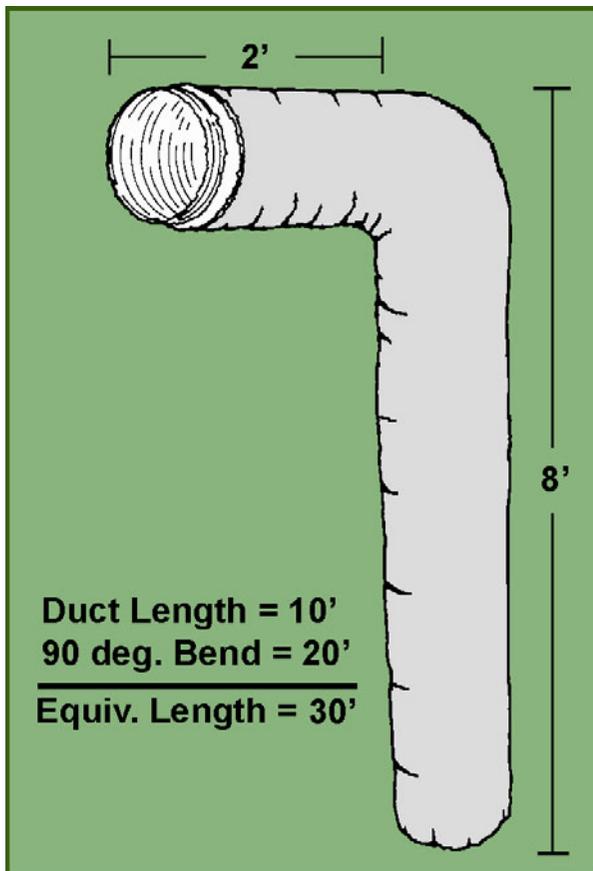


Figure 15

A gradual 45-degree bend has pressure drop equal to about ten (10) lineal feet of flexible duct. Add ten (10) equivalent feet to the length for each gradual bend (see Fig. 16).

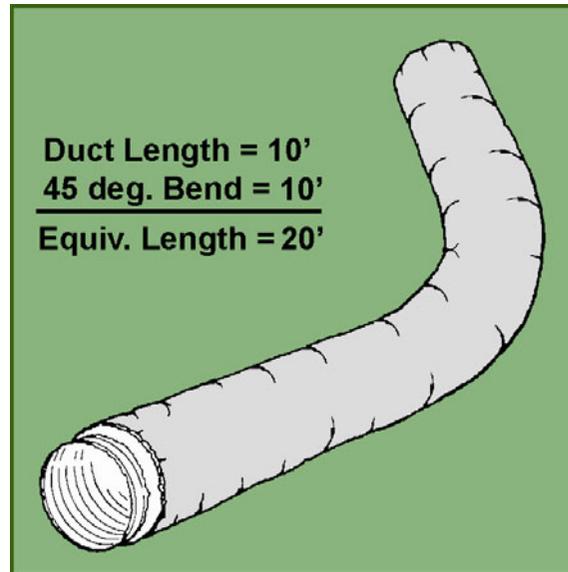


Figure 16

A 180-degree offset has pressure drop equal to about forty (40) lineal feet of flexible duct. Add forty (40) equivalent feet to the length for each sharp 180-degree offset.

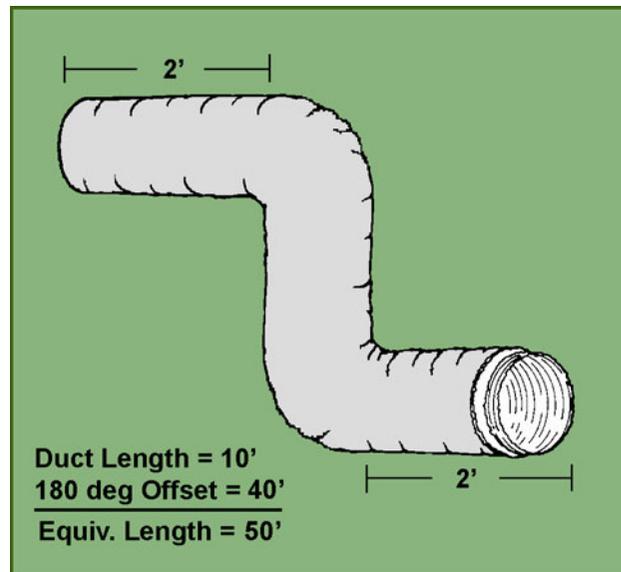


Figure 17

Installation Requirements . . . continued

Duct fittings and any bends and turns in flexible duct all produce a resistance to airflow. This resistance creates a pressure drop measured in inches water column (IWC) which is physically equivalent to the pressure drop produced by a straight section of duct. So the total pressure drop for any duct run equals the sum of the fitting pressure drops and the pressure drop of the straight duct section.

To determine the correct duct size, take into account the total equivalent length of the duct run, including entrance and exit losses from the plenum to the duct and from the duct into the terminal device, the added length due to any bends, and the total length of the duct itself.

Use ACCA Manual D (App. 3) equivalent length values for bends and fittings.

A typical duct run from plenum to terminal device is illustrated in Figure 18.

The worksheet for determining the total pressure drop of the duct run depicted in Figure 18 will look like this:

Entrance fitting =	35 ft.
Total duct length =	14 ft.
2 x 45° bends (2 x 10') =	20 ft.
1 x 90° bend (1 x 20') =	20 ft.
Exit fitting =	35 ft.

Total Equivalent Length = 124 ft.

Although the distance from plenum to terminal end in this example is approximately 12 feet, the total equivalent length used to determine the correct duct diameter would be 124 feet.

The equivalent length values for bends & fittings represented above are default values from ACCA Manual D and based on 900 fpm at 0.08 IWC/100' for supply ducts and 700 fpm at 0.08 IWC/100' for return ducts.

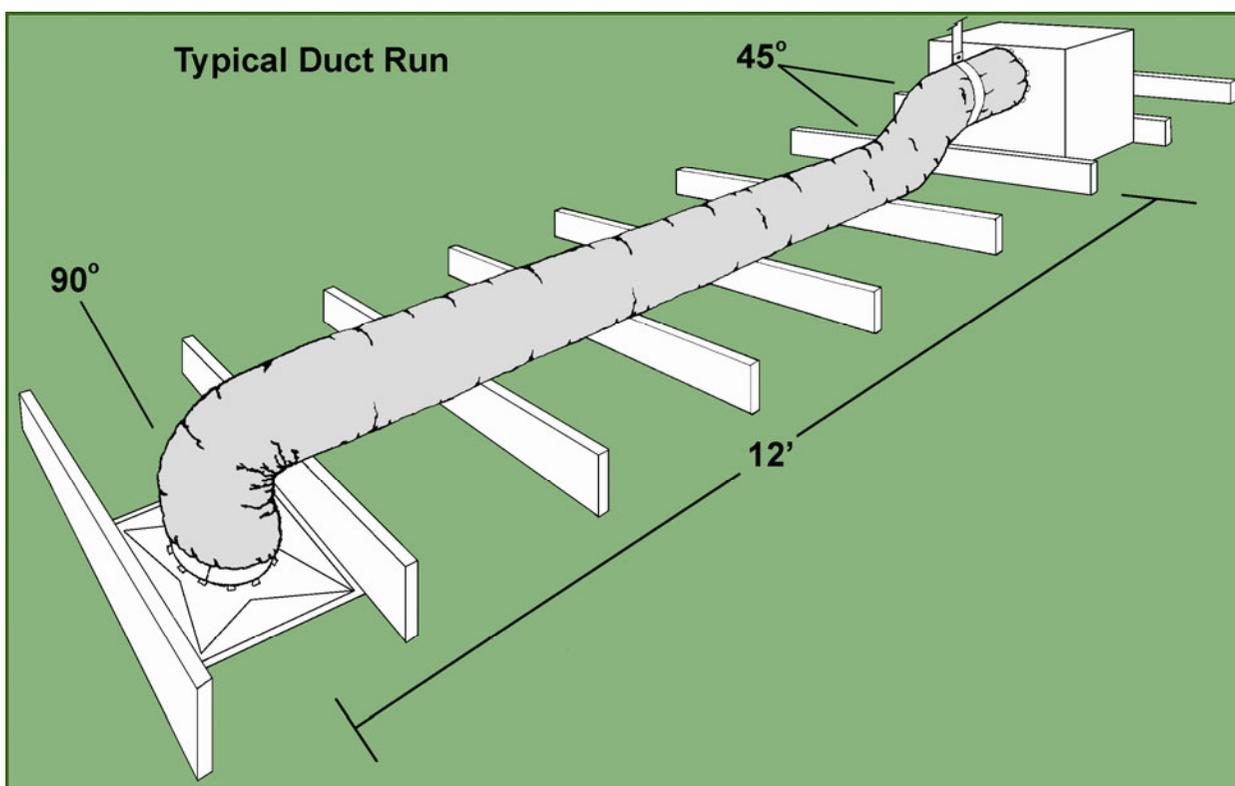


Figure 18

Installation Requirements . . . continued

4.6 Supporting Flexible Duct

Flexible duct shall be supported at manufacturer's recommended intervals, but at no greater distance than 4' [1.2 m]. Supporting shall be provided so that the maximum centerline sag is 1/2" per foot [42 mm per meter] of spacing between supports (See Fig 19). A connection to rigid duct or equipment may be considered a support joint.

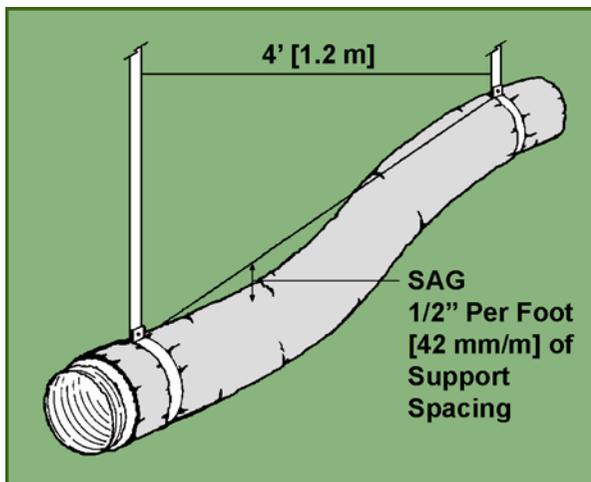


Figure 19

Long horizontal duct runs with sharp bends shall have additional supports before and after the bend approximately one duct diameter from the center line of the bend (See Fig 20).

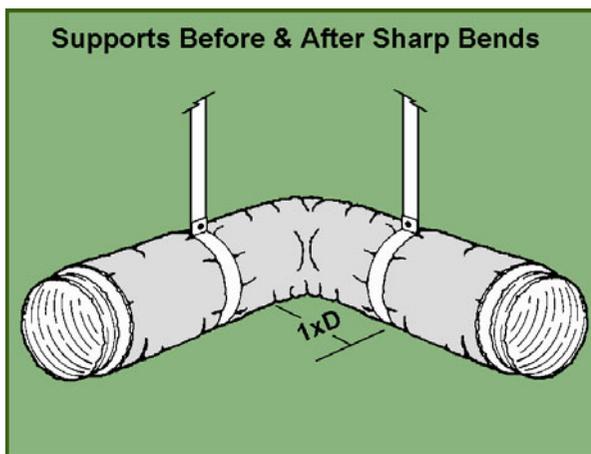


Figure 20

Hanger or saddle material in contact with the flexible duct shall be of sufficient width to prevent any restriction of the internal diameter of the duct when the weight of the supported section rests on the hanger or saddle material. In no case will the material contacting the flexible duct be less than 1 1/2" [38 mm] wide (See Fig 21).

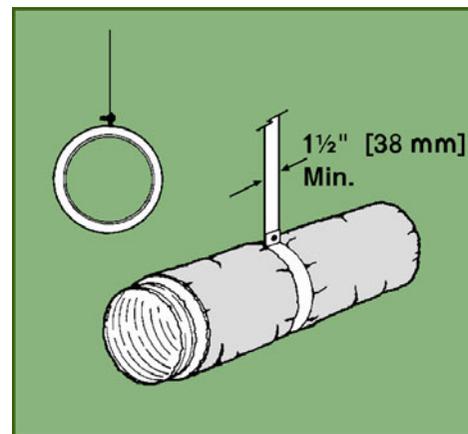


Figure 21

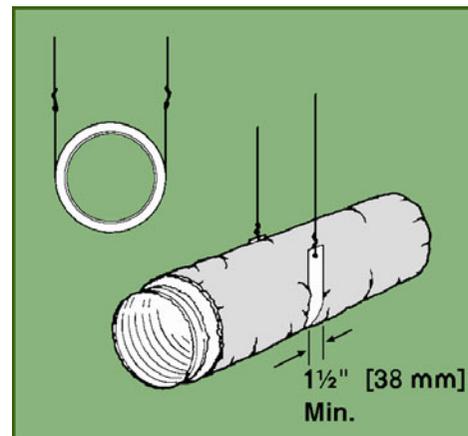


Figure 22

Do not secure support straps in a manner that compresses the inner core and constricts the air flow. Care shall be taken to insure the vapor barrier and insulation material are not excessively compressed by the support straps. Compressing the insulation could lead to condensation at the point of contact between the duct and the strap or saddle material.

Installation Requirements . . . continued

Factory installed suspension systems integral to the flexible duct are an acceptable alternative hanging method when manufacturer's recommended procedures are followed.

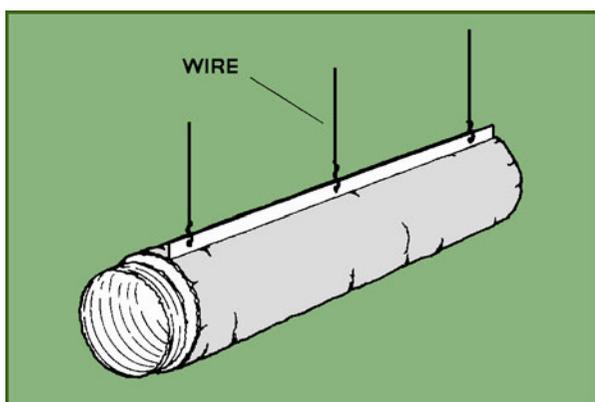


Figure 23

Support the duct between a metal connection and bend by allowing the duct to extend straight for at least one duct diameter before making the bend. This will avoid possible damage of the flexible duct by the edge of the metal collar and allow for efficient air flow and fitting performance (See Fig 25).

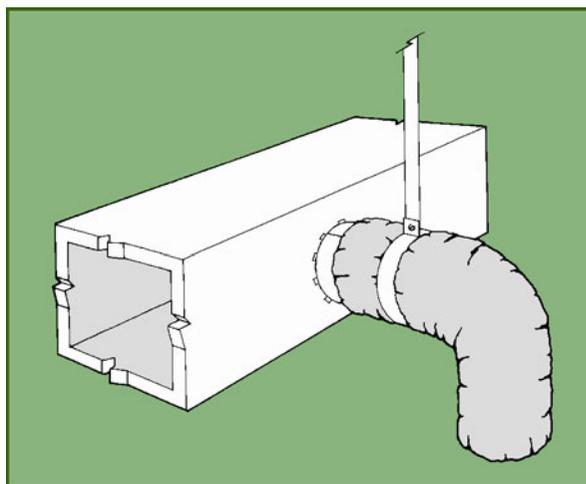


Figure 25

Flexible ducts may rest on ceiling joists or truss supports. Maximum spacing between supports shall not exceed the maximum spacing per manufacturer's installation instruction.

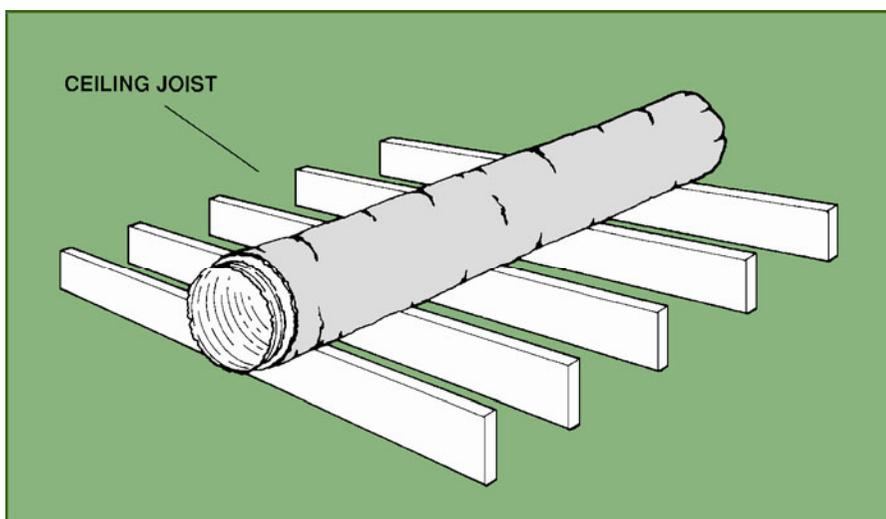


Figure 24

Note:

Factory-made air ducts may not be used for vertical risers in air duct systems serving more than two adjacent stories.

Vertically installed ducts shall be stabilized by support straps at a max. of 6' [1.8 m] on center.

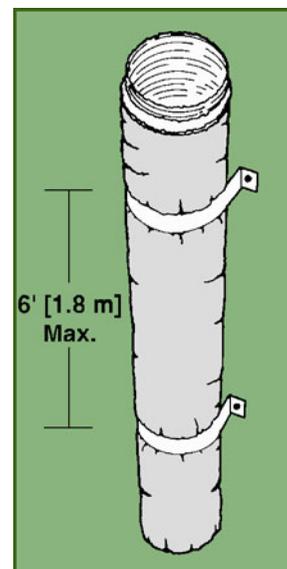


Figure 26

Installation Requirements . . . continued

4.7 Connecting, Joining and Splicing Flexible Ducts

All connections, joints and splices shall be made in accordance with the manufacturer's installation instructions.

Standardized installation instructions conforming to the connecting and sealing requirements of the national building codes and this standard are shown in Sections 4.7.1 through 4.7.3.

Section 4.7.1 - "Installation Instructions for Air Ducts and Air Connectors - Nonmetallic With Plain Ends" (uses tape and clamp to seal and secure the duct core to the fitting).

Section 4.7.2 - "Alternate Installation Instructions for Air Ducts and Air Connectors - Nonmetallic With Plain Ends" (uses mastic and clamp to seal and secure the duct core to the fitting).

Section 4.7.3 - "Installation Instructions for Air Ducts and Air Connectors - Metallic With Plain Ends (optional use of tape or mastic and metal screws to seal and secure the duct core to the fitting).

Due to the wide variety of ducts and duct assemblies with special end treatments (factory installed fittings, taped ends, crimped metal ends, etc.), only these standardized installation instructions are shown. Always reference the manufacturer's installation instructions for more detailed requirements.

All tapes, mastics, and nonmetallic clamps used for field installation of flexible ducts shall be listed and labeled to Standard UL 181B - Closure Systems for Use With Flexible Air Ducts and Air Connectors.

Sheet metal fittings to which flexible ducts with plain ends are attached shall be beaded and have a minimum of 2 inches [50 mm] collar length. Beads are optional for fittings when using metal worm-gear clamps or when attaching *metallic* flexible ducts using sheet metal screws.

Sheet metal sleeves used for joining two sections of flexible duct with plain ends shall be a minimum of 4 inches [100 mm] in length and beaded on each end. Beads are optional for sleeves when using metal worm-gear clamps or when joining *metallic* flexible ducts using sheet metal screws.

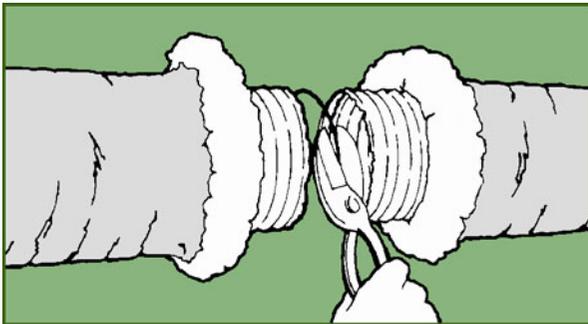
Flexible ducts secured with nonmetallic clamps shall be limited to 6 inches w.g. [1500 Pa] positive pressure.

Installation Requirements . . . continued

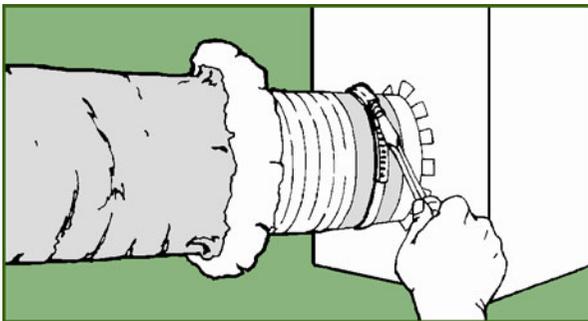
4.7.1 Installation Instructions for Air Ducts and Air Connectors - Nonmetallic with Plain Ends

Connections - Using Tape and Fasteners

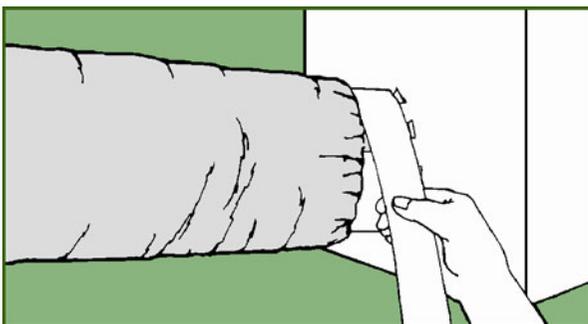
1. After desired length is determined, cut completely around and through duct with knife or scissors. Cut wire with wire cutters. Fold back jacket and insulation.



2. Slide at least 1" [25 mm] of core over fitting and past the bead. Seal core to collar with at least 2 wraps of duct tape. Secure connection with clamp placed over the core and tape and past the bead.

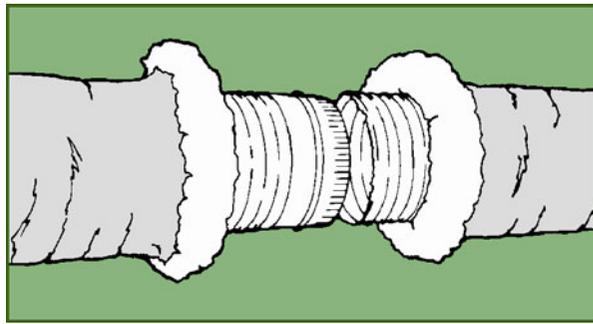


3. Pull jacket and insulation back over core. Tape jacket with at least 2 wraps of duct tape. A clamp may be used in place of or in combination with the duct tape.

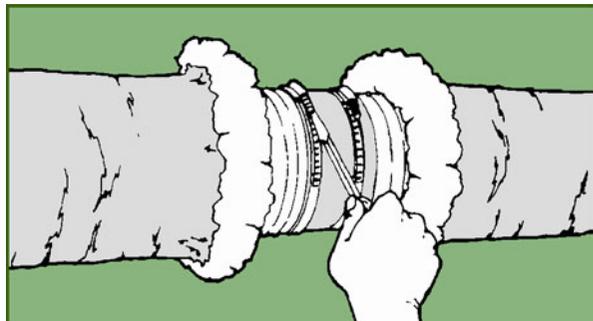


Splices - Using Tape and Fasteners

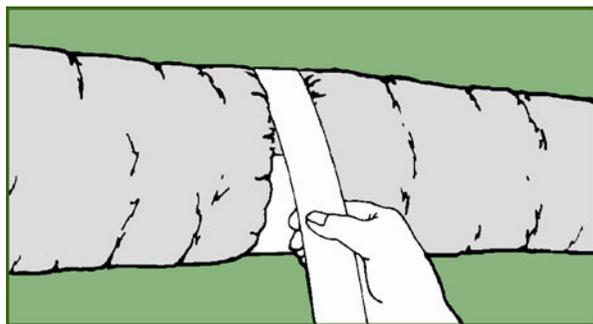
1. Fold back jacket and insulation from core. Butt two cores together on a 4" [100 mm] min. length metal sleeve.



2. Tape cores together with at least 2 wraps of duct tape. Secure connection with 2 clamps placed over the taped core ends and past the beads.



3. Pull jacket and insulation back over cores. Tape jackets together with at least 2 wraps of duct tape.



NOTES:

1. For uninsulated air ducts and air connectors, disregard references to insulation and jacket.
2. Use beaded sheet metal fittings and sleeves when using nonmetallic clamps.
3. Use tapes listed and labeled in accordance with Standard UL 181B and marked "181B-FX".
4. Nonmetallic clamps shall be listed and labeled in accordance with Standard UL 181B and marked "181B-C". Use of nonmetallic clamps shall be limited to 6 in. w.g. [1500 Pa] positive pressure.

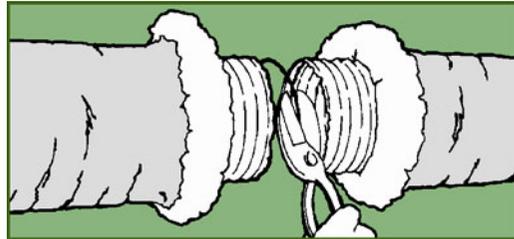
Installation Requirements . . . continued

4.7.2 Alternate Installation Instructions for Air Ducts and Air Connectors - Nonmetallic with Plain Ends

Connections and Splices - Using Mastic and Fasteners

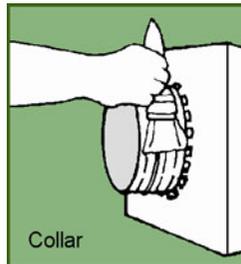
Step 1

After desired length is determined, cut completely around and through duct with knife or scissors. Cut wire with wire cutters. Pull back jacket and insulation from core.

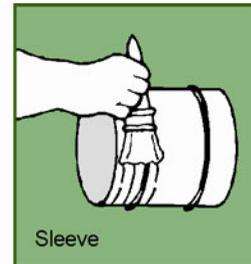


Step 2

Apply mastic approximately 2" [50 mm] wide uniformly around the collar of the metal fitting or over the ends of a 4" [100 mm] min. length metal sleeve. Reference data on mastic container for application rate, application thickness, cure times and handling information.



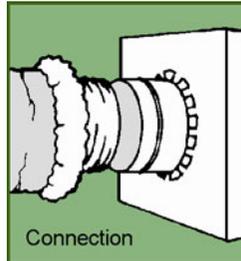
Collar



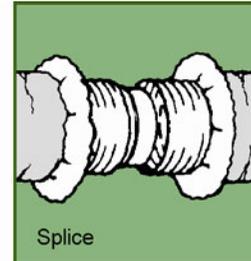
Sleeve

Step 3

Slide at least 2" [50 mm] of core over the fitting or sleeve ends and past the bead.



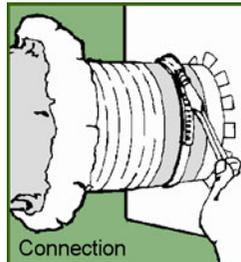
Connection



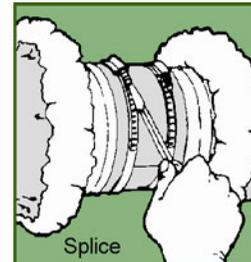
Splice

Step 4

Secure core to collar with a clamp applied past the bead. Secure cores to sleeve ends with 2 clamps applied past the beads.



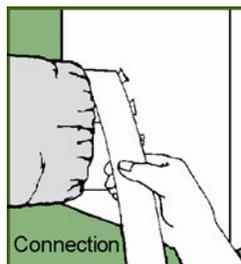
Connection



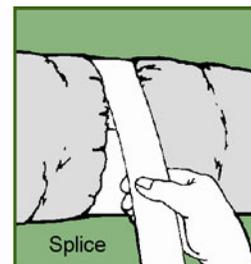
Splice

Step 5

Pull jacket and insulation back over core ends. Tape jacket(s) with at least 2 wraps of duct tape. A clamp may be used in place of or in combination with the duct tape.



Connection



Splice

NOTES:

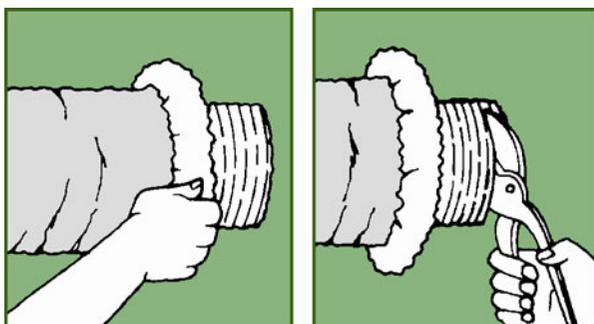
1. For uninsulated air ducts and air connectors, disregard references to insulation and jacket.
2. Use beaded sheet metal fittings and sleeves when using nonmetallic clamps.
3. Use mastics listed and labeled in accordance with Standard UL 181B and marked "181B-M" on container.
4. Use tapes listed and labeled in accordance with Standard UL 181B and marked "181B-FX".
5. Nonmetallic clamps shall be listed and labeled in accordance with standard UL 181B and marked "181B-C". Use of nonmetallic clamps shall be limited to 6 in. w.g. [1500 Pa] positive pressure.

Installation Requirements . . . continued

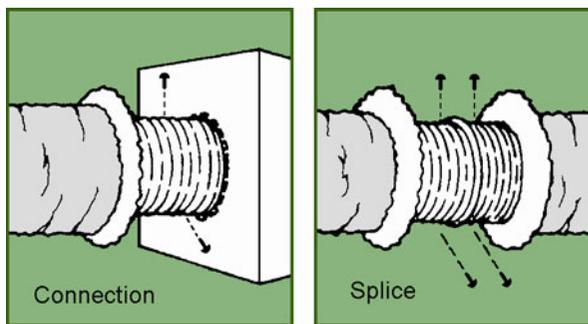
4.7.3 Installation Instruction for Air Ducts and Air Connectors - Metallic with Plain Ends

Connections and Splices - Using Tape or Mastic and Sheet Metal Screws

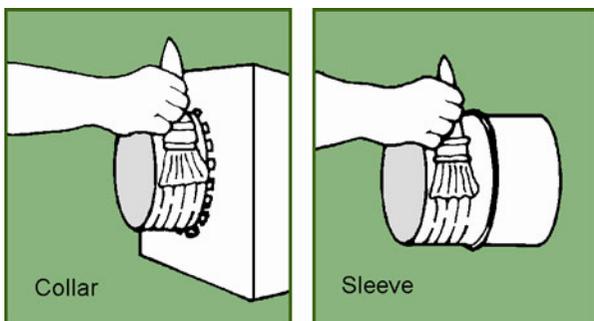
1. After cutting duct to desired length, fold back jacket and insulation exposing core. Trim core ends squarely using suitable metal shears. Determine optional sealing method (Steps 2 or 5) before proceeding.



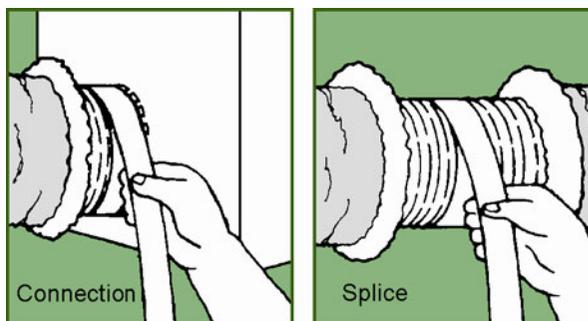
4. Secure to collar/sleeve using #8 sheet metal screws spaced equally around circumference. Use 3 screws for diameters under 12" [300 mm] and 5 screws for diameters 12" [300 mm] and over.



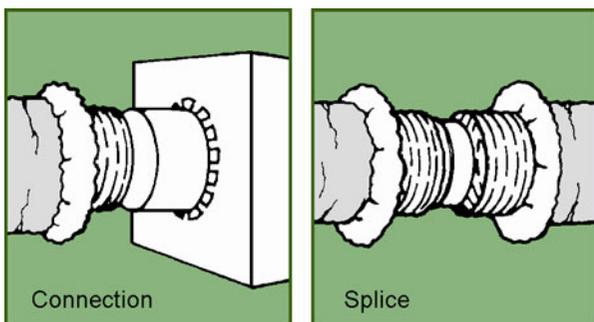
2. When mastics are required and for pressures 4" w.g. [1000 Pa] and over, seal joint with mastic applied uniformly to the outside surface of collar/sleeve. (Disregard this step when not using mastics and proceed to Step 3).



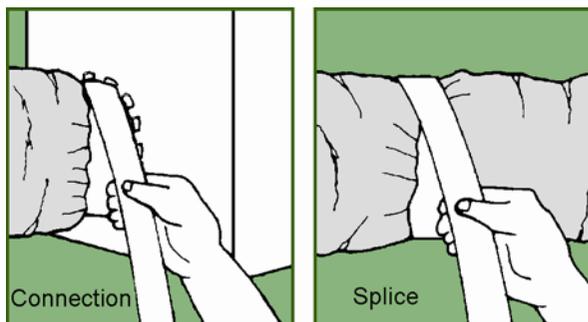
5. For pressures under 4" w.g. [1000 Pa] seal joint using 2 wraps of duct tape applied over screw heads and spirally lapping tape to collar/sleeve. (Disregard this step when using mastics per Step 2).



3. Slide at least 1" [25 mm] of core over metal collar for attaching duct to take off or over ends of a 4" [100 mm] metal sleeve for splicing 2 lengths of duct.



6. Pull jacket and insulation back over core. Tape jacket with 2 wraps of duct tape. A clamp may be used in place of or in combination with the duct tape.



NOTES:

1. For uninsulated air ducts and air connectors, disregard references to insulation and jacket.
2. Use mastics listed and labeled to Standard UL 181B and marked "181B-M" on container.
3. Use tapes listed and labeled to Standard UL 181B and marked "181B-FX".
4. Nonmetallic clamps shall be listed and labeled in accordance with Standard UL 181B and marked "181B-C".

Typical Accessories

5.1 Types

These figures depict typical accessories but do not represent all available accessories. The designer should select and approve accessories which are acceptable for each application taking into account the inherent pressure loss characteristics of the selected accessory (Refer to ACCA Manual D and ASHRAE Fundamentals). This standard is not intended to limit the selection or the development of accessories for use with flexible duct.

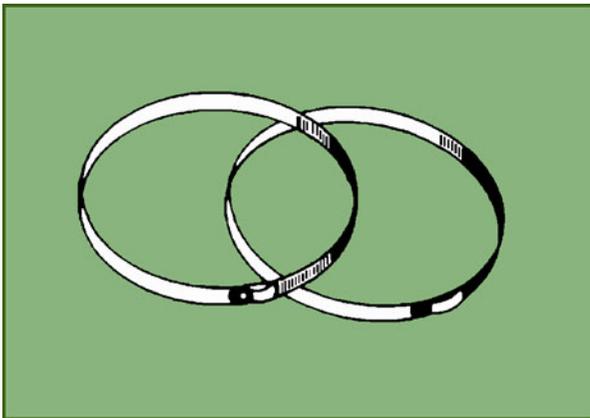


Figure 27 Metal Duct Clamp

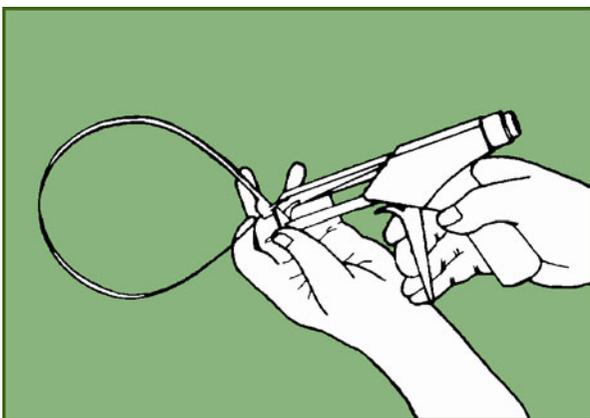


Figure 28 Nonmetallic Mechanical Fastener, Shall be listed to UL181B

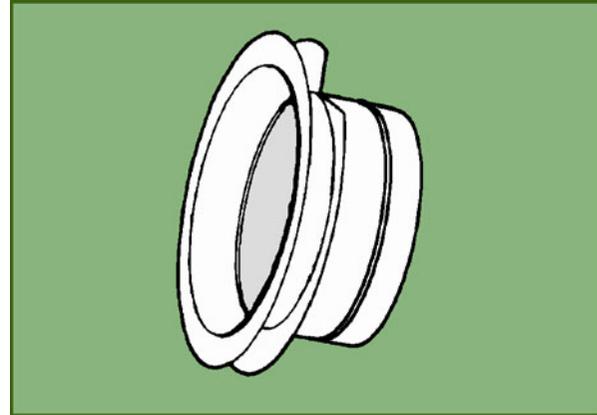


Figure 29 Ductboard Collar (Spin-In)

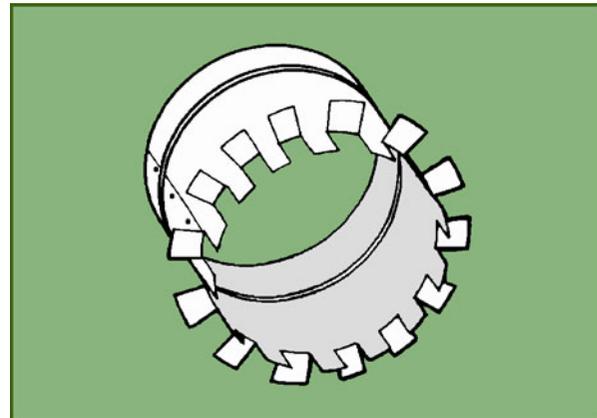


Figure 30 Sheet metal Collar (Dovetail)

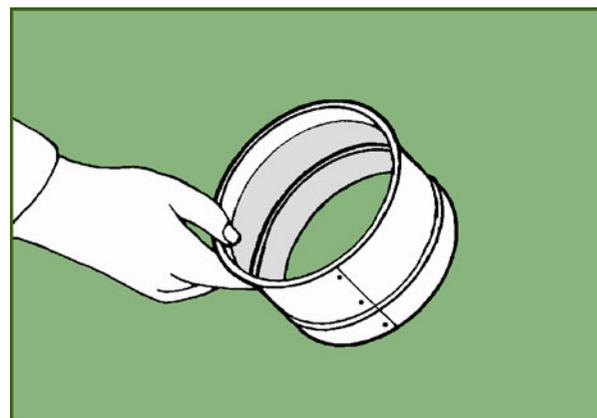


Figure 31 Sheet metal Collar (Spin-In-Straight)

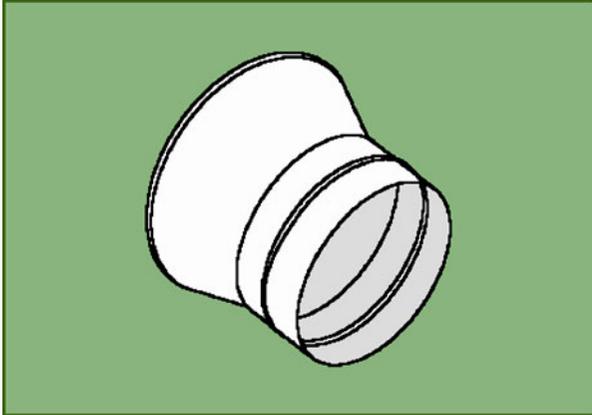


Figure 32 Conical Collar (Spin-In)

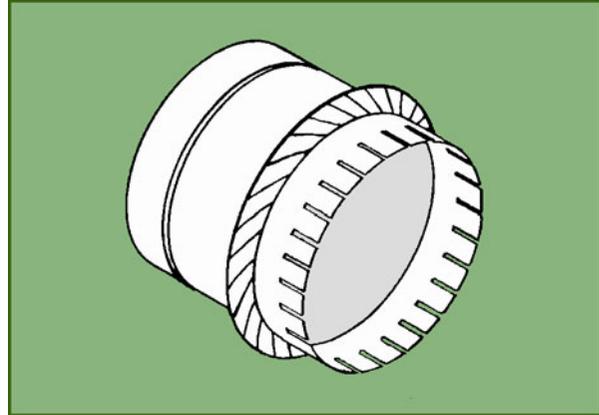


Figure 35 Ductboard Collar (Tabbed)

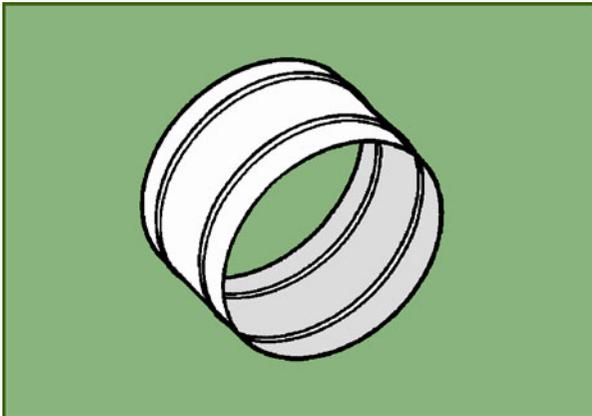


Figure 33 4" [100 mm] min. length Sleeve/Coupling

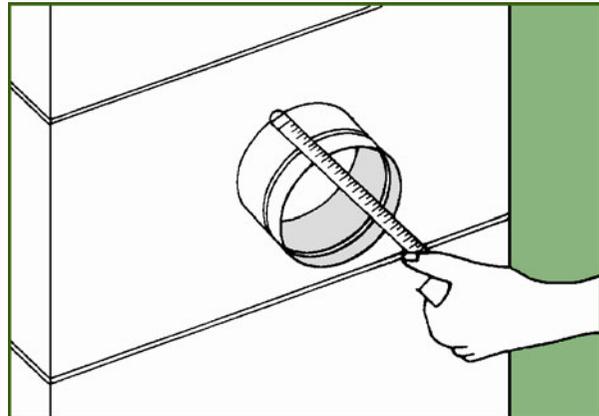


Figure 36 Insulated Box with Collar (2" [50 mm] length min.)

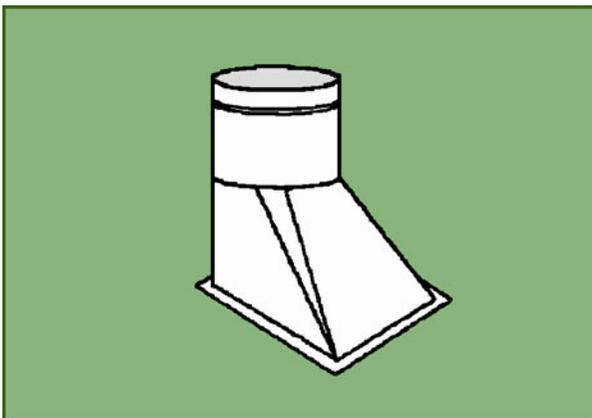


Figure 34 45° Entry Fitting

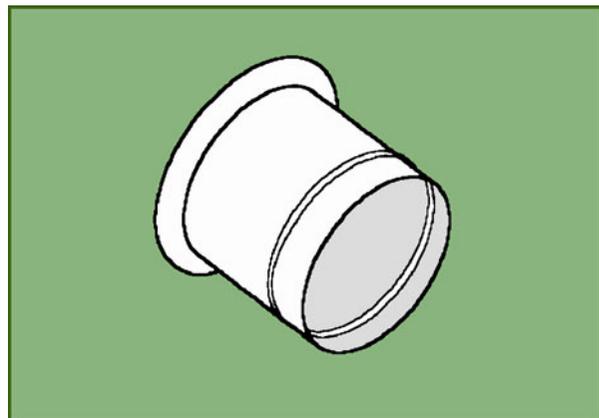


Figure 37 Flanged Fitting

General Commentary

6.1 Fire Safety

Flexible ducts cannot be considered “noncombustible”, except metallic non-insulated ducts, but they are generally regarded as “limited-combustible”. The UL 181 Safety Standard for “Factory-Made Air Ducts and Air Connectors” is used to investigate safety performance as referenced in the applicable International Codes (ICC), Uniform Mechanical Code (IAPMO), the applicable National Fire Protection Code/Standards (NFPA), and various other state and local codes.

The UL 181 Standard has been used for more than 40 years for evaluating safety. The testing procedures were developed by taking a wide range of safety-related installation situations into consideration, including structural integrity and flammability characteristics. Four (4) fire tests are used to investigate the flammability and burning characteristics of flexible duct as follows:

- a. The Surface Burning Characteristics (Flame Spread and Smoke Development) for both interior and exterior of duct using the 25 ft. [7.6 m] tunnel test method that is published in UL 723, the American Society of Testing and Materials (ASTM E84), the National Fire Protection Association (NFPA 255) and the American National Standards Institute (ANSI).
- b. Ease of ignition/burning test using a Bunsen burner on both the inner core and outer jacket of the duct.
- c. Flame penetration test using a specially designed test apparatus to evaluate the retardation of flame passage from exterior to interior of the duct.
- d. Component flame resistance test conducted on tapes, fabrics, adhesives, and related components that are exposed directly to the air system.

6.2 Duct Leakage

Flexible duct has inherently low leakage properties due to the impervious nature of the materials used as the air barrier. These give the flexible duct itself leakage rates less than ½ of 1% of air volume when proper connections are made to other system components.

A higher than expected leakage rate can occur at connections if improper materials or careless work practices are used. To assure a low leakage rate for flexible duct systems, the following is required:

- a. Reference applicable industry manuals (SMACNA, NAIMA) for making round tap-ins into and sealing fitting joints to rigid ducts, plenums, etc.
- b. Make flexible duct connections/splices in accordance with the manufacturer’s recommended installation instructions or this Standard.
- c. Seal flexible duct connections with sealing materials listed and labeled to Standard UL 181B. Mechanically secure connections with approved clamping material.
- d. Repair any rip, tear or hole in the air barrier using materials listed and labeled to Standard UL 181B and methods recommended by the manufacturer.



6.3 Thermal Resistance (R-value Rating)

The thermal resistance (R-value) requirements for air distribution ducts can vary depending on the energy code being enforced. For insulated ducts, the minimum thermal value in conformance with this standard is R-4.2 [0.74]. Uninsulated ducts have no R-value rating. To accommodate the varying levels of R-values required by the building codes, ADC manufacturers commonly offer insulated flexible duct with R-value ratings of 4.2 [0.74], 6.0 [1.06] and 8.0 [1.41].

Thermal resistance (R-value) for this standard is determined in accordance with *Thermal Performance* in Section 3.4. The value, excluding any film resistance, is determined on flat sections of insulation only at installed duct wall thickness and in accordance with ASTM C518 at 75°F [24°C] mean temperature. R-values based on dynamic thermal tests are not part of this standard.

6.4 Certification of Thermal Performance

For credence, ADC maintains a third-party verification of R-value ratings in accordance with *Thermal Performance* in Section 3.4 and *Certification* in Section 3.8 of this standard. An adjunct testing and follow-up program is established with Underwriters Laboratories Inc. for flexible ducts listed and labeled to Standard UL 181. This program includes testing, classifying, follow-up testing and labeling of R-values at both the insulation manufacturer and the flexible duct manufacturer. ADC members participating in this rigorous thermal certification program are eligible to mark their product with the “ADC Seal of Certification for Thermal Performance” as shown below.



Thermal Performance

6.5 Field Alterations

Flexible ducts complying with this standard are listed to the UL 181 Safety Standard for “Factory-Made Air Ducts and Air Connectors” and shall be installed per the conditions of their listing.

Alterations made in the field, such as applying additional overwraps of insulation or barriers, adding spray-foam insulation, surface painting, applying internal sanitizers or spray sealants, etc. may compromise the fire safety performance of the duct and void the manufacturer’s listing and/or product warranty.

6.6 Exposure to UV Radiation and Sunlight

Some polymeric materials used to manufacture nonmetallic flexible ducts will degrade with prolonged exposure to ultraviolet (UV) radiation. UV radiation occurs naturally in sunlight or can be artificially generated by specialized lamps.

The outer barrier (jacket) may degrade if ducts are installed outside in direct sunlight or within attics, crawl spaces, etc. where direct sunlight enters, e.g. turbine vents, sky lights, canopy windows, etc.

The inner core (liner) may degrade if ducts are positioned near a bio-treatment lamp (UV emitter) installed within the HVAC system.

Unless the product is specifically designed to withstand the exposure to UV light, care should be taken to ensure the outer vapor barrier and inner core material are shielded from direct sunlight and UV radiation. Reference the manufacturer’s recommendations for specific product information related to UV exposure.



Notes

