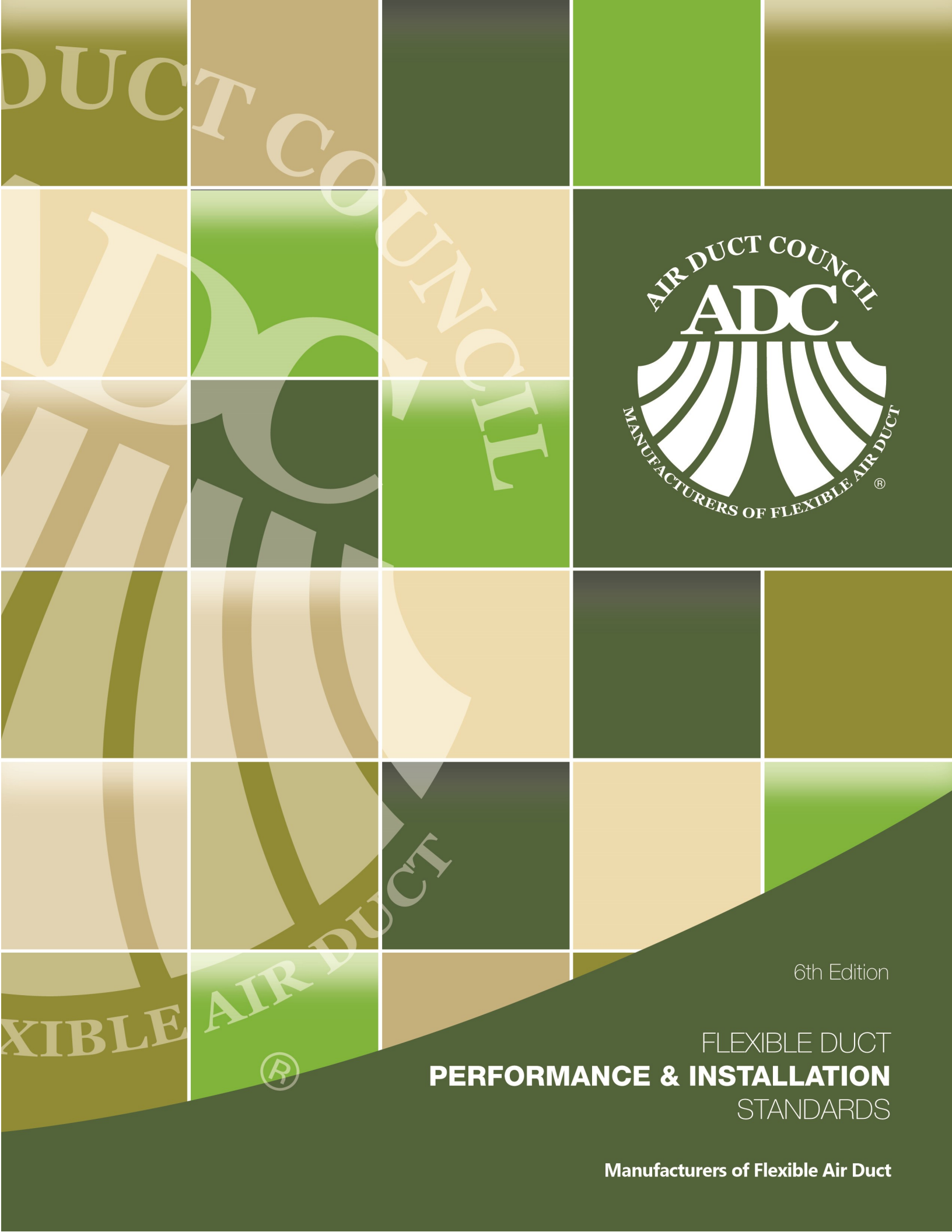

6th Edition

FLEXIBLE DUCT **PERFORMANCE & INSTALLATION** STANDARDS

Manufacturers of Flexible Air Duct

Flexible Duct Performance and Installation Standards

Sixth Edition

AIR DUCT COUNCIL
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Mission Statement of The Air Duct Council

The purpose for which the Air Duct Council is formed as stated in its Certification of Incorporation, are in general 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 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 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 and supported more vigorously and effectively in legal association with others who share those interests*.

ADC Bylaws, Article 1, Section 2 (2013*)*

Table of Contents

INTRODUCTION

Introduction

The Air Duct Council Flexible Duct Performance & Installation Standards (Greenbook) was first introduced to the HVAC industry in 1980. This standard has been the installation and performance guideline for the flexible duct industry for many years.

This edition seeks to make it easier to locate topics of interest for installers, inspectors, designers and homeowners. Each chapter addresses a specific interest, but it was written in a way that is easy for anyone to follow and understand regardless of background or expertise in HVAC.

Disclaimers

As with all the previous editions the information contained within this document is a recommendation of best practices based on the available knowledge of the members of the ADC. Authorities considering adoption and/or reference of this standard should review all federal, state, local and other applicable regulations. The Air Duct Council assumes no responsibility nor accepts any liability for the application or techniques contained in the standard.

CHAPTER SUMMARY

Chapter 1 Scope

Establishes the breadth of this document.

Chapter 2 Common Terms

Establishes some commonality of terms. Some terms in this document may be unfamiliar or uncommon to the readers. To help reduce confusion some of the more important terms have been defined in this section.

Chapter 3 Design

The Design information in this manual is for informational purposes, and to answer many typical design questions. The best sources for designing a duct system can be found in ACCA Manual D for Residential Buildings and ACCA Manual Q for Commercial Buildings.

Chapter 4 Inspection & Installation

Emphasis for inspectors and installers. Examples of the proper way to install flexible ducting. A checklist found in Appendix D is a handy tool for anyone interested in the proper installation of flexible ducting.

Chapter 5 Care

Common questions regarding duct replacement and/or duct cleaning.

Chapter 6 Performance

Performance standards that the ADC has determined are important to ensure that customers receive the best possible product.

Chapter 7 Reference Standards

The list of standards referenced in this document.

CHAPTER 1: SCOPE

This standard sets forth instructions for properly installing flexible ducts in air distribution systems. 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.

Flexible ducts shall be categorized as either Air Ducts or Air Connectors in accordance with testing and listing requirements in Appendix B.

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

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

Ducts shall be listed in conformance to NFPA Standard 90A & 90B.

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

CHAPTER 2: COMMON TERMS

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 (Co) at a specified bend radius ratio. Co 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 (IWC) 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.

COMMON TERMS

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·m^2·Pa)].

Pressure
The positive or negative static pressure expressed in inches of water gauge (IWC) [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/(m-°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 [(m^2-°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 electro-magnetic spectrum lying between visable light (380nm) and x-rays (100nm).

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].

CHAPTER 3: DUCT DESIGN

3.1 Installation Restrictions and Use Limitations

3.1.1 Flexible Duct Installation

Flexible ducts shall be installed in accordance with the conditions of their listing and manufacturers installation instructions.

3.1.1.1 Shall not be installed in concrete, buried below grade or in contact with the ground.

3.1.1.2 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.

3.1.2 Flexible Air Connectors Installation

3.1.2.1 Shall not be installed in lengths greater than 14 ft. [4.3 m] for any given run.

3.1.2.2 Shall not be spliced together with short collars to circumnavigate the 14 ft. [4.3 m] limitation.

3.1.2.3 Shall not pass through any wall, partition or enclosure of a vertical shaft with a 1 hour or more fire resistive rating and shall not pass through floors.

3.1.3 Vertical Risers

Shall not be used for vertical risers serving more than two stories in height.

3.1.4 Temperature Limitations

Shall not be used in systems with enter air temperature higher than 250°F [121°C].

3.1.5 Duct Penetrations

Shall not penetrate a wall where fire dampers are required.

3.1.6 Additional Uses

Shall not be used to vent appliances for cooking, heating, fireplaces, and clothes drying unless approved and recommended by the appliance manufacturer.

3.2 Benefits

Flexible air ducts provide multiple benefits and advantages.

Foremost, except for those intentionally perforated for acoustical purposes, flexible air ducts have impervious inner liners—meaning they have zero leakage when properly connected and sealed. This attribute is instrumental in helping systems achieve the extremely low leakage levels desired today by most building owners.

In addition flexible air ducts come pre-insulated with multiple R-value offerings. This allows for lower duct installation costs as the ducts do not have to be wrapped and sealed after-the-fact.

Flexible air ducts also have inherently better sound attenuation performance due to the non-rigid inner liner. Net insertion loss values are higher as compared to standard sheet metal pipe.

Flexible duct are densely packaged allowing for easier transport to the job site and can be more easily routed around building obstructions.

When properly sized and installed per the procedures in this standard, flexible air ducts are a cost effective and efficient option for HVAC duct systems.

3.3 Common System Layouts

Most HVAC systems are designed as Radial, Trunk & Branch, or a mixture of the two systems. Some examples of these systems are shown below.

3.3.1 Radial System

Radial Duct Systems also commonly referred to as spider configurations; generally consist of a supply plenum that is centrally located to the conditioned space. Duct runs branch off the plenum typically in a radial pattern to supply individual spaces with specific heating/cooling requirements.

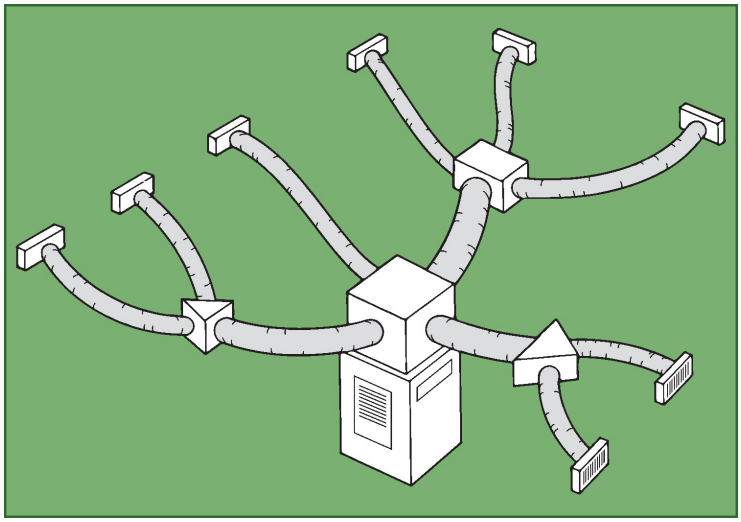


Figure 1

3.3.2 Trunk & Branch Systems

Trunk and Branch Systems consist of a main supply plenum with large diameter takeoffs to support the main supply of air flow. As the main supply ducts/extended plenums progress smaller diameter take off branches supply individual spaces with specific heating/cooling requirements. Sometimes longer trunks will need to be reduced in order to maintain proper flow rates.

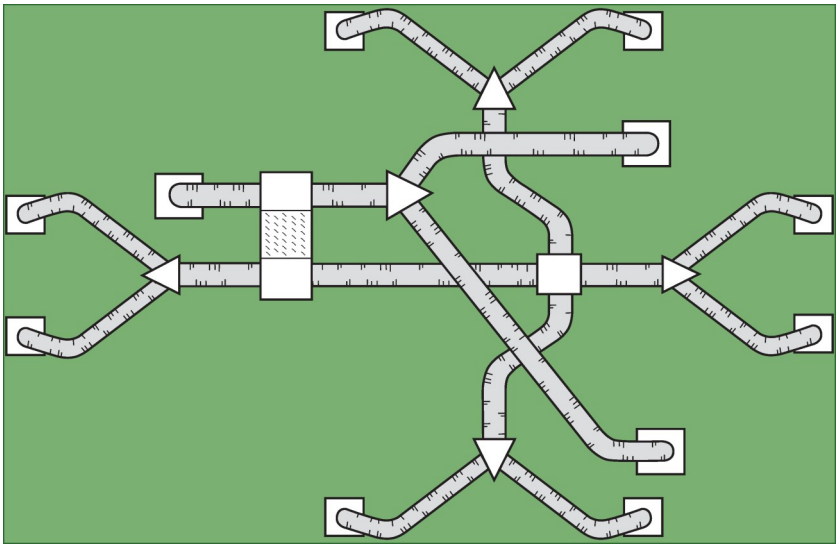


Figure 2

DUCT DESIGN

3.4 Sizing

An efficient HVAC system must include properly sized ducts, regardless of duct type, shape, or configuration. Ducts should be sized according to the predetermined energy loads in order to provide necessary heating or cooling throughout the space. Oversizing or under sizing ductwork can lead to unbalanced air distribution and added strain for the HVAC unit resulting in energy loss.

The fan in an HVAC system generates positive pressure in the system which results in the flow of air through the ductwork as it seeks equilibrium. As the air flows through the ducts the positive pressure decreases due to friction from the duct surface characteristics, changes in direction from bends, wyes, etc. This decrease is referred to as pressure drop, or friction loss, and it can be measured in inches water column (IWC).

Each system component, direction change, etc. 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. For example—a 90 degree bend in flexible duct is considered to be 20 equivalent feet of duct because it exhibits the same pressure drop as 20 feet of straight duct (see Figures 4, 5, & 6).

In determining the correct size, sum the total equivalent length of the duct run, including straight duct, bends, fittings, mixing boxes, and entrance and exit losses (See Figure 3 and example below). Size the duct using this total pressure drop value.

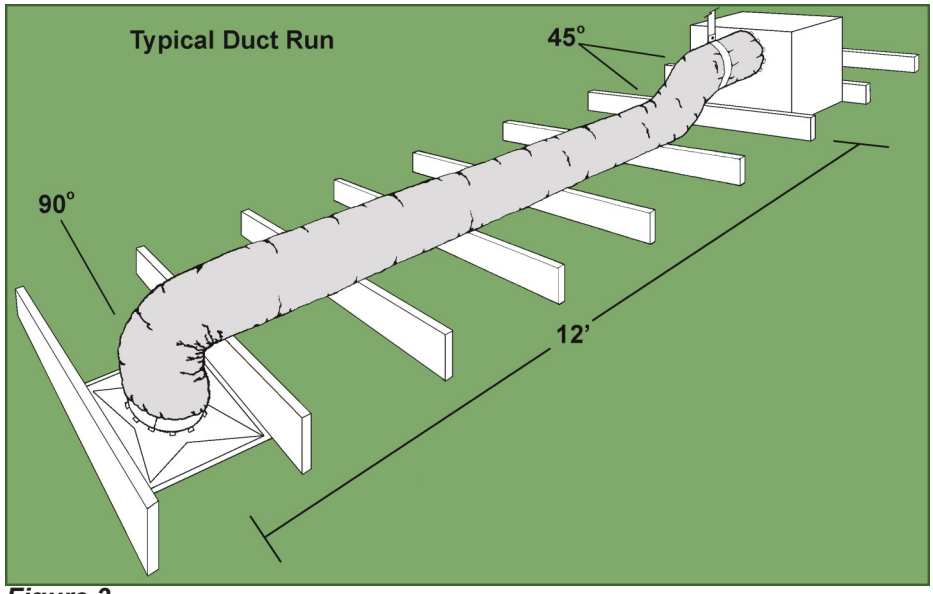


Figure 3

The worksheet for determining the total pressure drop of the duct run depicted in Figure 3 will look like this:

Entrance fitting =	35 ft.
Total duct length =	12 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 =	122 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 122 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. The flexible duct system should be designed per the requirements of ACCA Manual D Residential Duct Design and Manual Q Commercial Duct Design.

DUCT DESIGN

When determining the proper duct size the equivalent length for bends must be used.

90-degree Bend (Figure 4)
A 90-degree bend has pressure drop equal to approximately twenty (20) lineal feet of flexible duct.

45-degree Bend (Figure 5)
A gradual 45-degree bend has pressure drop equal to about ten (10) lineal feet of flexible duct.

180-degree Offset (Figure 6)
A 180-degree offset has pressure drop equal to about forty (40) lineal feet of flexible duct.

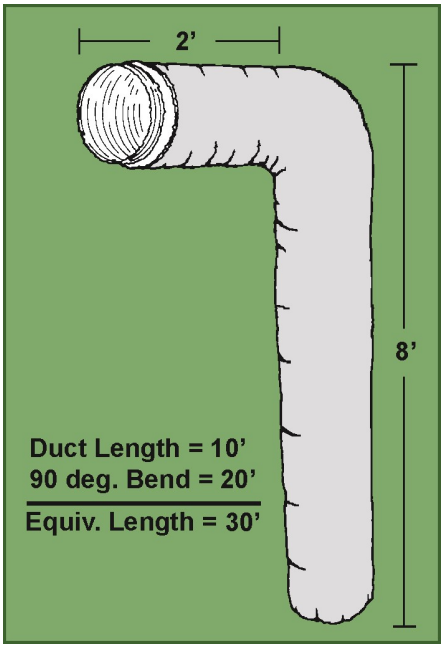


Figure 4

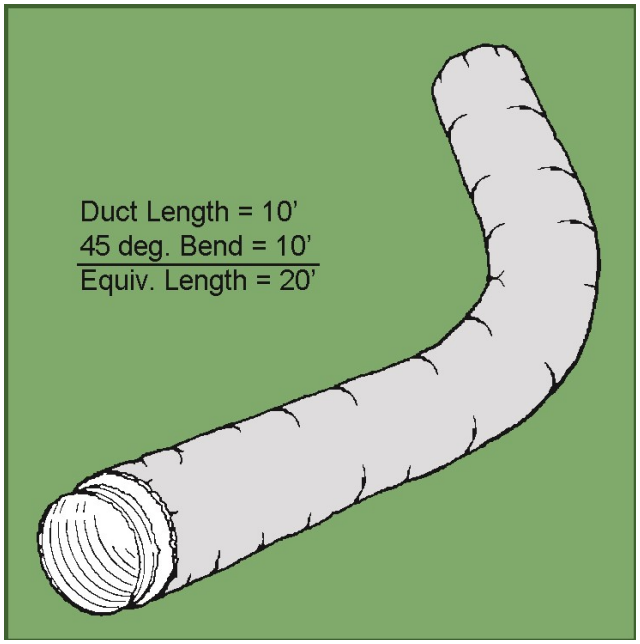


Figure 5

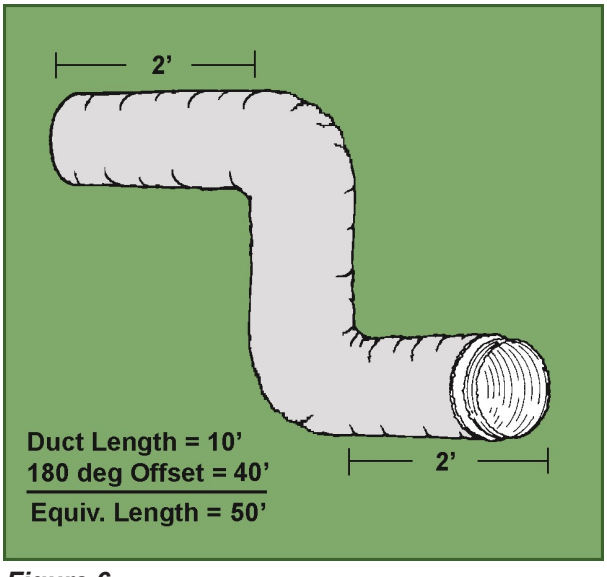


Figure 6

3.5 Thermal Performance

Flexible Duct Media (FDM) is used to resist the flow of energy in insulated flexible air duct. Heat flows into the duct during cooling or out of the duct during heating. The quantity of heat flowing into or out of the duct is controlled by the FDM's thermal resistance — commonly called R-value. Requirements for air distributing duct R-values vary depending on the energy code being enforced. The minimum R-value in conformance with this standard is R-4.2 [0.74]. To accommodate these requirements, ADC manufacturers insulated flexible duct with R-value ratings of R4.2 [0.74], 6.0 [1.06], and 8.0 [1.41]. Special applications may call for R-values beyond 8.0. Uninsulated ducts are considered to have no R-value rating. Flexible duct R-values shall be based on insulation only and not include air barriers, air films, vapor barrier, or other ducting components.

Some helpful equations and terms related to Thermal Resistance, Thermal Conductance, and Thermal Conductivity are listed below. Heat Transfer is always from the hot side to the cold side of the insulation.

3.5.1 Thermal Conductivity (k and λ)

Thermal conductivity is a material property of FDM and the measure of its ability to conduct heat flowing through unit thickness per unit area per degree of temperature. It is often abbreviated as k in IPS units or λ n SI units.

3.5.2 Thermal Conductance (C-value)

Thermal Conductance is the measure of the ability of the FDM to conduct heat flowing through an actual FDM thickness per unit area per degree of temperature.

Equation 1: C-value = (k or λ) / (thickness of FDM when laid flat at room temperature conditions)

3.5.3 Thermal Resistance (R-value)

Thermal Resistance is the measure of the ability of the FDM to resist heat flowing through an actual FDM thickness.

Equation 2: R-value = 1 / C-value

Equation 3: R-value = (thickness of FDM when laid flat at room temperature conditions) / (k or λ)

3.6 Thermal Performance Certification

ADC maintains a third-party verification and certification protocol for flexible duct R-value ratings in accordance with Sections 6.2.1 and 6.6.1 of this standard.

A testing and follow-up program was established with UL and ETL in 1993 for flexible ducts listed and labeled to the UL181 Standard. This program includes testing at the flexible duct and the insulation manufacturer's locations to classify component materials and flexible ducts. Continued follow-up testing at the factories insures continued R-Value classification.

The program test method measures the thermal conductivity (k) value for the insulation at the intended duct wall thickness and verify the flexible duct components are manufactured to provide the required wall thickness to achieve the R-Value. Thermal performance ratings are based on the conductivity value for the insulation when tested in a flat configuration and do not include air barriers, air films, vapor barrier, or other ducting components.

Most building codes emphasize the above requirements for determining duct R-Values and include language indicating duct insulation R-Values shall be based on the insulation and the installed wall thickness only. Look for the ADC Seal of Certification for Thermal Performance.

Thermal Performance

3.7 UV light

Some polymeric materials used to manufacture nonmetallic flexible ducts may degrade with prolonged exposure to ultraviolet (UV) light 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 exposure to UV radiation from sunlight or from specialized lamps, special care shall be taken to ensure the outer vapor barrier and inner core material are shielded from the direct path of such radiation. Reference the manufacturer's recommendations for specific product information related to UV exposure.

3.8 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/Standard (NFPA), and various other state and local codes.

The UL 181 Standard has been used for more than 40 years for evaluating duct 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:

3.8.1 Surface Burning per UL 181 Section 7

The Surface Burning Characteristics (Flame Spread and Smoke Development) for both interior and exterior duct using the 25 ft. [7.6m] 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)

3.8.2 Burning Test per UL 181 Section 11

Ease of ignition/burning test using a Bunsen burner on both the inner core and outer jacket of the duct.

3.8.3 Flame Penetration Test per UL 181 Section 10

Flame penetration test using a specifically designed test apparatus to evaluate the retardation of flame passage from exterior to interior of the duct.

3.8.4 Flame Resistance Test per UL 181 Section 8

Component flame resistance test conducted on tapes, fabrics, adhesive, and related components that are exposed direction to the air system.

3.9 Fire Resistance-Rated Assemblies

A fire-resistance rating refers to the period of time an assembly is able to contain a fire and perform its intended structural function. UL's product category for Fire-resistance Ratings (BXUV) covers fire-rated assemblies for floor-ceilings, roof-ceilings, beams, columns, walls and partitions based upon the test method and acceptance criteria in UL 263 (ASTM E119), "Fire Tests of Building Construction and Materials." The ratings are expressed in hours (i.e. - 1 hour fire rating). When an assembly complies with the test criteria, a detailed description of the assembly, its performance in the fire test, and other pertinent specifications for materials, certification coverage and alternate assembly details are included in the fire resistive assembly report. These assemblies are published on UL's Online Certifications Directory Product iQ, www.ul.com/PiQ. Many designs allow the use of Class 0 or Class 1 flexible air ducts and air connectors. This directory of fire-resistance designs should be consulted to determine the requirements for air ducts within a particular assembly design.

3.10 Bathroom Exhausts and Vents

Flexible air ducts and air connectors listed and labeled in accordance to UL 181 are required to pass UL 181 Section 13 Mold Growth and Humidity Test. This test ensures that materials in air ducts are resistant to high humidity conditions and that mold introduced to the duct surface will not grow or spread. This testing requirement along with proper installation will allow flexible air ducts and connectors to be used in bathrooms as well as other high humidity applications or applications with the potential for mold growth.

Ducts used for exhausting bathrooms and vents in cold weather climate zones shall be insulated in order to avoid issues with condensation collecting on the inside surface of the ducts.

3.11 Deeply Buried Duct

The Air Duct Council is aware that certain local, state, and national building codes allow for the practice of encapsulating ducts within additional insulation materials. Additionally the codes allow for partially or deeply burying ducts under blown-in insulation when installed in attics. Although this can be considered an energy efficient method for improving the overall thermal performance of the system, encapsulating or burying ducts that already contain an outer vapor barrier can potentially lead to moisture problems when the ducts are installed in areas of the country conducive to condensation such as ASHRAE Climate Zones 1A, 2A, and 3A. In addition, encapsulating flexible ducts may invalidate the manufacturers listing to the UL181 Standard and/or the warranty. Care should be taken when considering the practice of encapsulating or burying a flexible duct system in this manner.

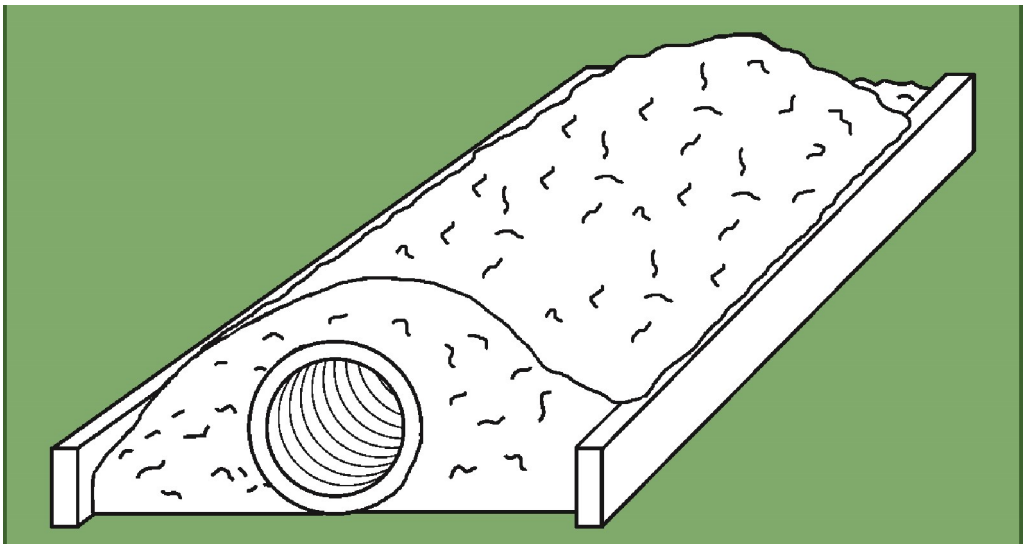


Figure 7

CHAPTER 4: INSPECTION & INSTALLATION

4.1 Installation Key Points

SIZED - Flexible duct shall be properly sized per the requirements of ACCA Manual D or Manual Q as applicable .

Time should be taken to complete sizing calculations for air distribution systems. This is not specific to flexible duct systems, any ducting system should be properly sized per the requirements of ACCA Manual D (Residential) or Manual Q (Commercial).

ROUTED - Flexible duct runs shall be properly routed to minimize sagging and "snaking"

Ducting systems should ALWAYS run in the most direct path from starting point to termination point. Every unnecessary turn or sag in the duct increases friction and reduces air flow.

EXTENDED - Flexible duct shall be installed fully extended using the minimum length needed to make connections.

Along with being installed in the most direct path the ducting should be fully extended. Ducting that is not extended can increase pressure drop and reduce air flow.

BENDED - Flexible duct bends shall be greater than or equal to 1 duct diameter.

Sharp bends in ducting significantly increase pressure drop. Keep bends to great than or equal to one (1) duct diameter and properly supported.

SUPPORTED - Flexible ducts shall be properly supported.

Duct supports shall be a minimum of 1.5" in width with wider supports recommended in installation areas conducive to condensation. Horizontal duct runs shall be supported at maximum 4' intervals and vertical risers at maximum 6' intervals.

SEPARATED - Flexible ducts should be separated in areas conducive to condensation.

To prevent condensation forming on the outer surface of the duct, a gap should be present to allow free air flow over the outer duct surface. Locations where two duct surfaces are in contact can lead to condensation.

SEALED - Flexible duct connections shall be properly sealed using listed and labeled sealing materials and methods.

Care shall be taken to properly seal the ducting using materials listed and labeled to the UL standard. Improper sealing and installation methods can lead to leakage which can reduce system efficiency.

> ***Note: An Installation Checklist can be found in Appendix E of this manual. This checklist can be used by installers or inspectors to ensure that the ducting is installed properly.***

4.2 Air Duct or Air Connector

Flexible ducts are classified by their performance when tested to UL 181 Standard for Safety, Factory-Made Air Ducts and Air Connectors. The standard includes seventeen (17) tests covering fire testing, tests for physical characteristics, and product performance testing. Sixteen (16) test are applicable to Air Ducts and thirteen (13) tests are applicable to Air Connectors. One (1) is reserved for testing Joining Materials. (Refer to Appendix B for testing detail.)

In many cases, Air Ducts and Air Connectors look similar in appearance. The only way to be sure whether a flexible duct is an Air Duct or Air Connector is to examine the **listing label** on the product.

- Flexible Air Ducts will have a rectangular or square listing label and include the words "Air Duct".
- Air Connectors will have a circular listing label which identifies it as an "Air Connector". In addition, Air Connectors will include the words "For installation in lengths not over 14 ft."

4.3 Bends

When making bends to flexible air ducts or air connectors, the diameter of the bend shall be greater than or equal to one (1) duct diameter (see Figures 8 & 9). If the bends are less than one (1) duct diameter this can significantly increase pressure drop throughout the system resulting in a reduction in the overall system efficiency and performance.

For bends made prior to or after a metal connection, extend the duct straight for at least one duct diameter length before and after the connection points. This avoids potential damage to the duct from the fitting edges while also improving the airflow.

For proper support, place strapping both before and after a 90 degree bend that is made in the middle of a duct run.

CORRECT BENDS

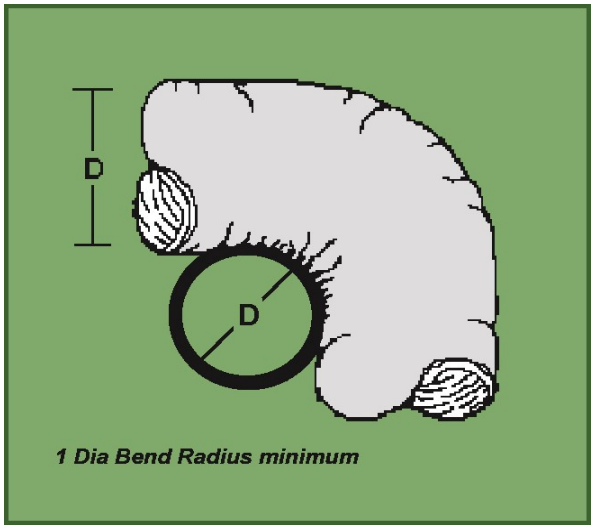


Figure 8

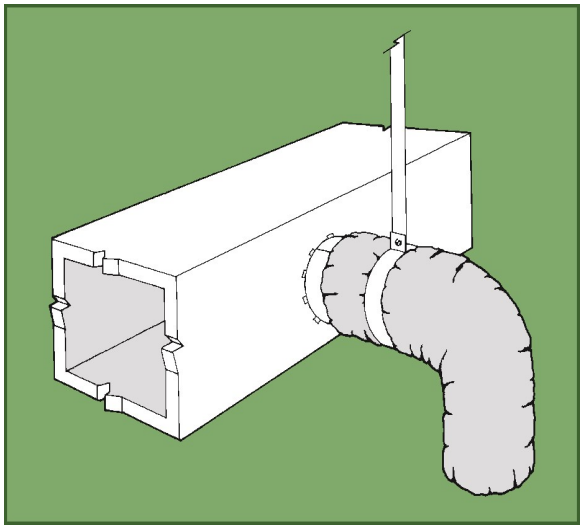


Figure 9

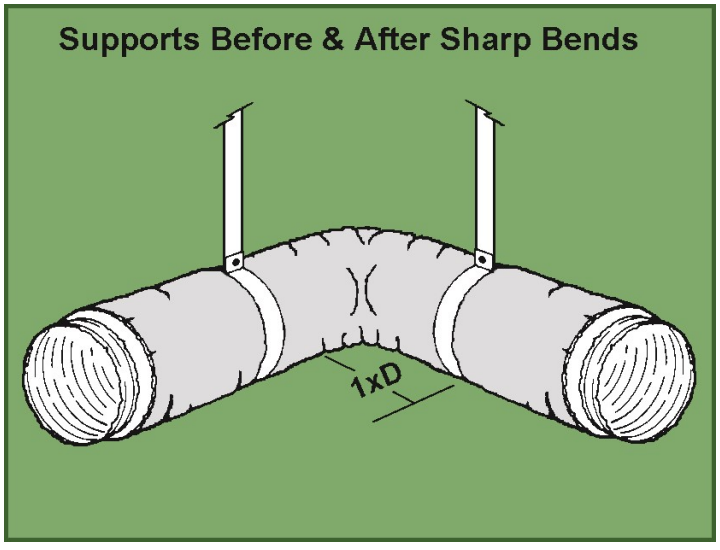


Figure 10

INCORRECT BENDS

Ducts shall not be crimped tightly against joist or truss members, or against pipes, wires, and other building materials.

Duct runs shall be made with the minimum practical length needed to make the connection from one fitting to the next. Excessive duct length and bends increase pressure drop and reduce overall system efficiency and performance. Ducts shall not be installed with excess length intended for future building changes.

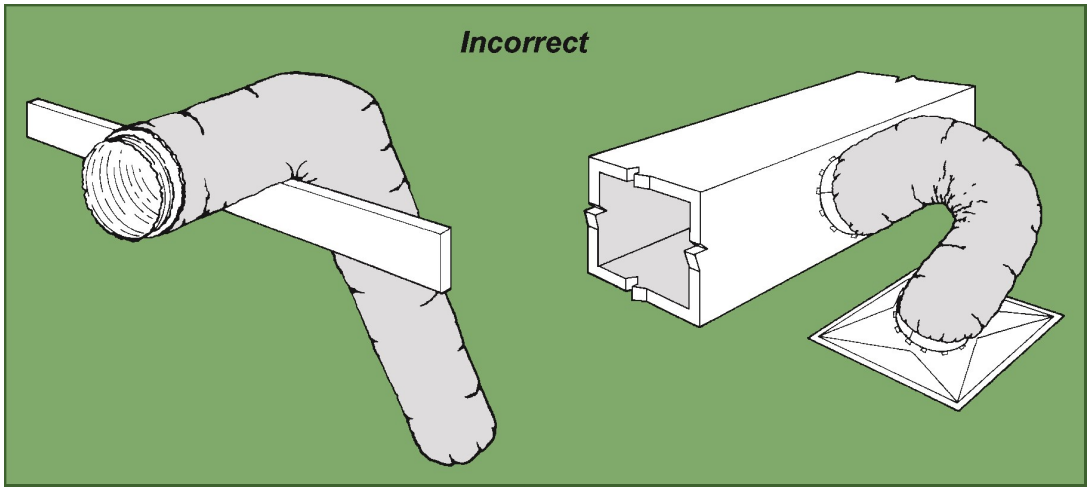


Figure 11

4.4 Routing, Sagging, & Snaking

Flexible air ducts and connectors should always be installed in the most direct route possible. Changing directions multiple times will increase the friction rate of the duct thus decreasing the air flow in the HVAC system.

Flexible air ducts and connectors must be installed in the straight condition without sag. Extra supports should be used to prevent sag where 90° bends are made by placing straps both before and after the bend. Excessive sag creates more friction reducing air flow in the air distribution system.

INCORRECT ROUTING

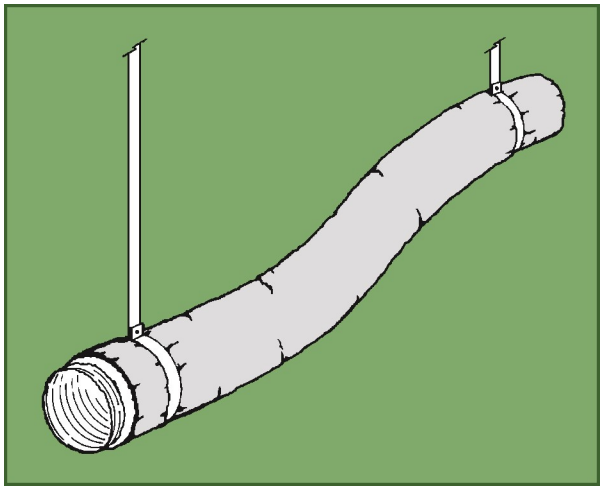


Figure 12

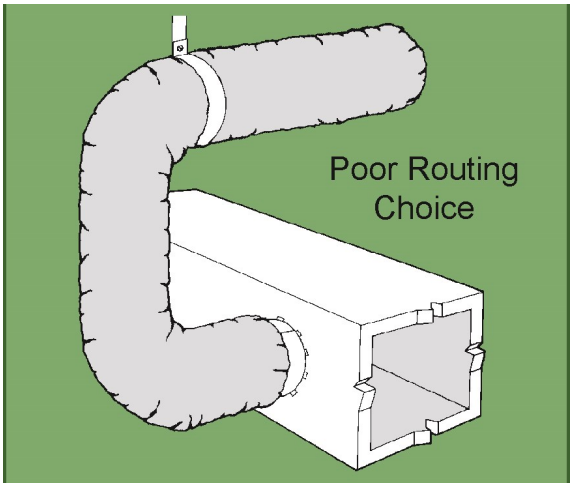


Figure 13

4.5 Supporting Flexible Ducts

4.5.1 Hanger Straps Material & Width.

Various materials are used regionally to hang and support flexible air duct. The ADC does not specify a particular material in our installation instructions. However, ADC does make the following statement:

Hanger or saddle material in contact with Flexible Air Ducts and/or Flexible Air Connectors shall be of sufficient width and rigidity to prevent any restriction of the internal diameter of the duct when the weight of supported sections rests on the hanger or saddle material. In no case will the material contacting the duct or connector be less than 1-1/2" wide.

For flexible duct installed in Climate Zones 1A, 2A, and 3A (refer to the IECC US Climate Zone Map) where higher levels of heat and humidity are likely it is recommended that a hanger or saddle material be not less than 3" wide to support the flexible duct. This recommendation is to reduce the likelihood of condensation at the point of contact with the hanging material and flexible duct due to compression of the fiberglass insulation potentially caused by the supporting material and the weight of the duct.

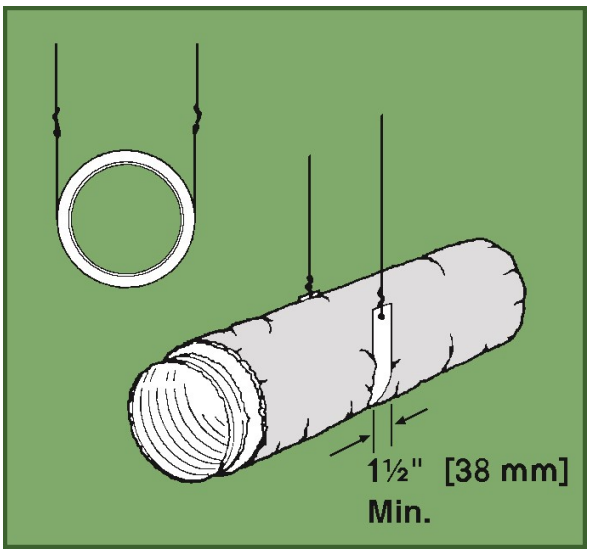


Figure 14

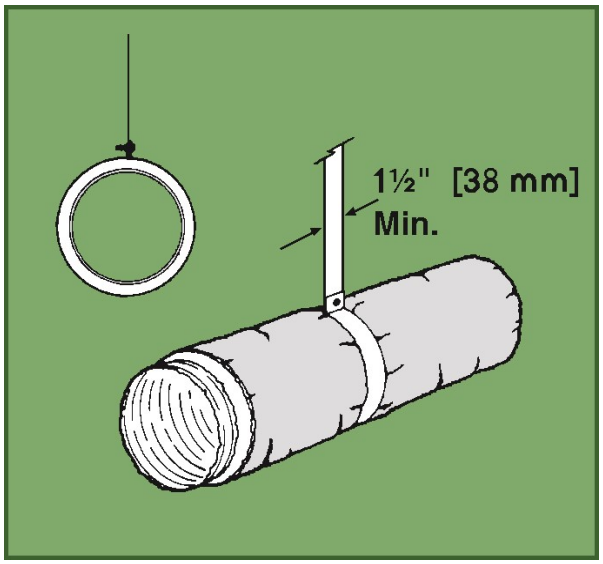


Figure 15

4.5.2 Support Spacing

Flexible duct shall be supported at maximum 4’ intervals horizontally and 6’ intervals for vertical risers.

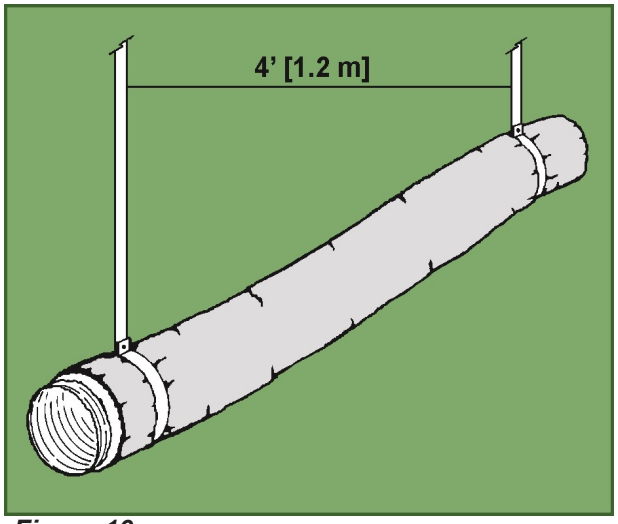


Figure 16

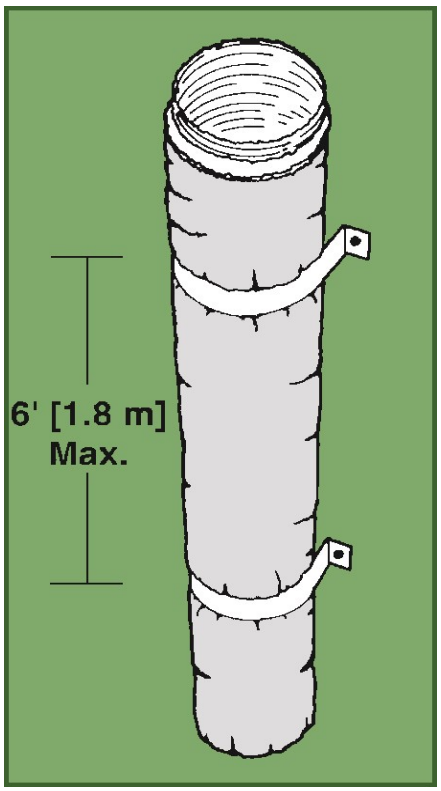


Figure 17

4.5.3 Ceiling or Truss Supports

Ceiling beams or truss members may be used to support flexible duct provided they do not exceed 4’ intervals, and are at least 1 ½” wide.

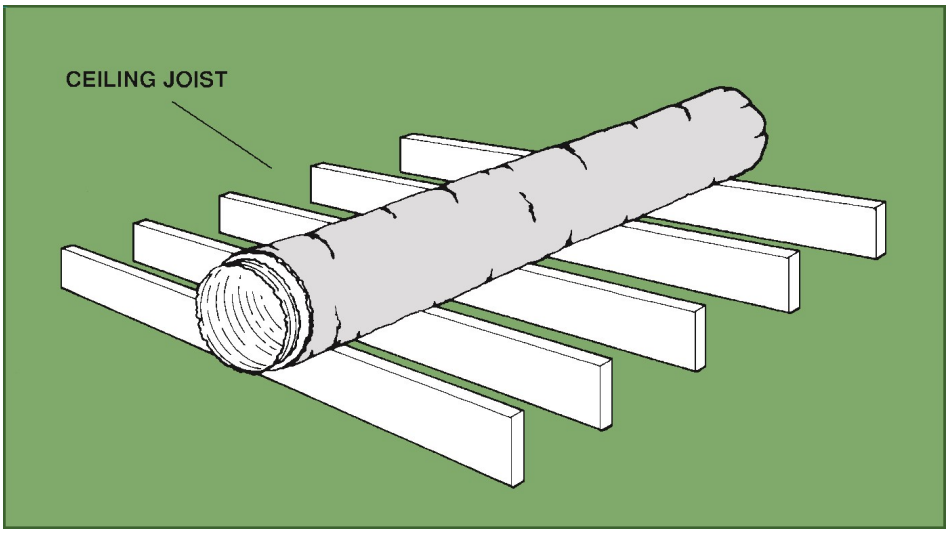


Figure 18

4.6 Compression

Unnecessary longitudinal and circumferential compression of flexible duct significantly increases pressure drop resulting in reduced air flow and loss of system efficiency. Care should be taken to insure flexible ducts are installed fully extended and not compressed.

A simplified, yet easily understood, comparison can be made by looking at the common garden water hose. Kinking a garden hose reduces or chokes off the water flow. Also, a long garden hose will have lower water pressure than a much shorter one. Movement of air through ducts is effected in the same manner.

4.6.1 Longitudinal Compression.

Flexible air ducts and air connectors should always be installed to their fullest length without longitudinal compression. Due to the helical configuration of flex duct inner cores, excess longitudinal compression significantly increases pressure drop and reduces performance. (See Figure 19)

4.6.2 Circumferential Compression.

Flexible air ducts and air connectors are intended to be installed in their original round configuration. For optimal air flow, care should be taken to avoid compressing the duct circumferentially along its length. Ducts should not be forced into small building cavity areas that result in compression of the duct wall and/ or the duct inner liner diameter. Incidental compression when connecting to oval pipe or fittings is acceptable. Compressing the duct vapor barrier and insulation can reduce the duct thermal performance characteristics and could also result in localized condensation. (See Figure 20)

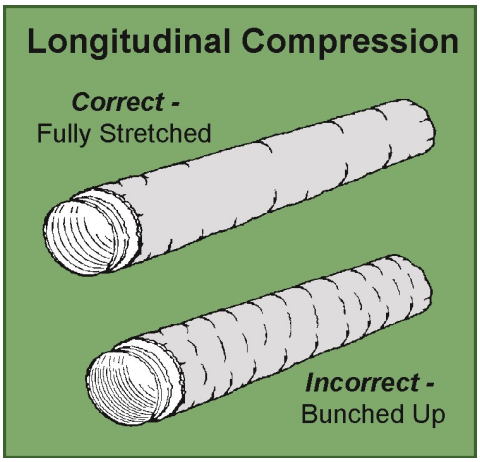


Figure 19

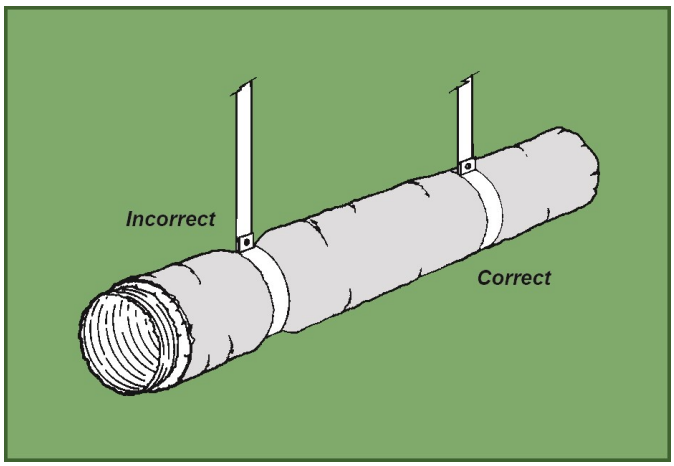


Figure 20

4.7 Installation Instructions

All connections, joints and splices shall be made in accordance with the manufacturer's installation instructions. Always reference the manufacturer's installation instructions for more detailed requirements.

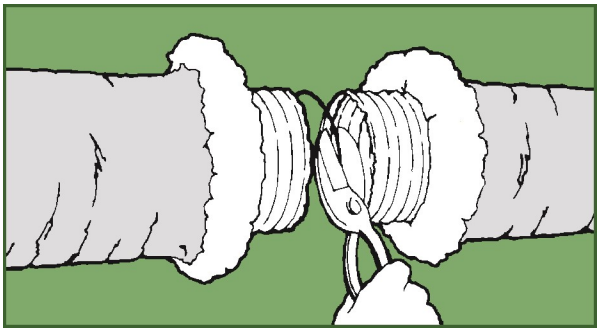
Due to the wide variety of ducts and duct assemblies with special end treatments (factory installed fittings, taped ends, crimped metal ends, etc.), only the standardized installation instructions were shown.

INSPECTION & INSTALLATION

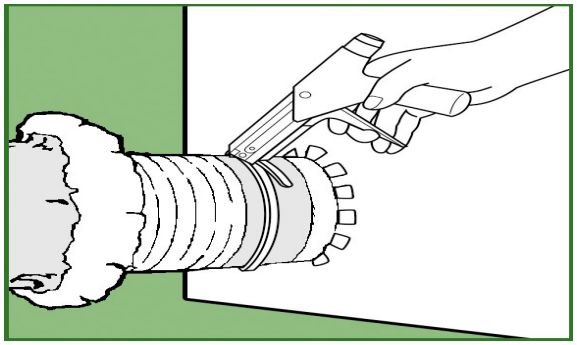
4.7.1 Installation Instructions for Air Ducts and Air Connectors - Nonmetallic with Plain Ends

Connections - Using Tape and Fasteners

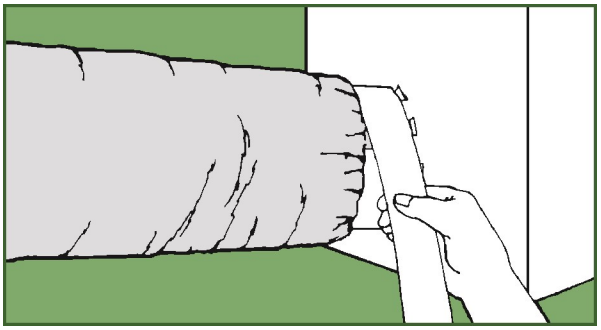
1. After desired length is determined, cut completely around and through duct with knife or scissors. Cut wire with wire cutters. Fold back jacket and insulation.



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.

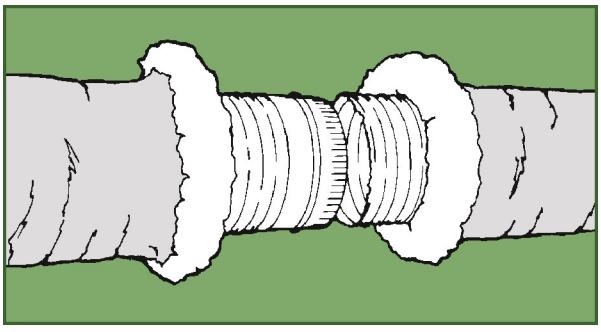


3. Pull jacket and insulation back over core. Tape jacket with at least 2 wraps of duct tape. A clamp may be used in place of or in combination with the duct tape.

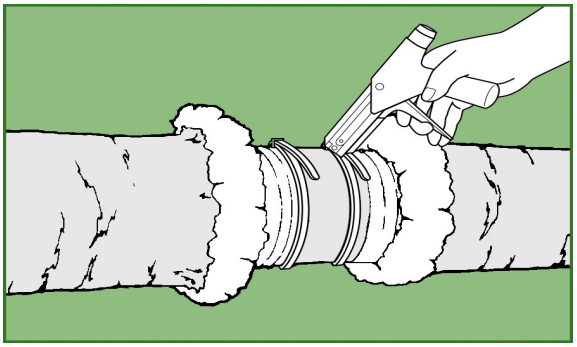


Splices - Using Tape and Fasteners

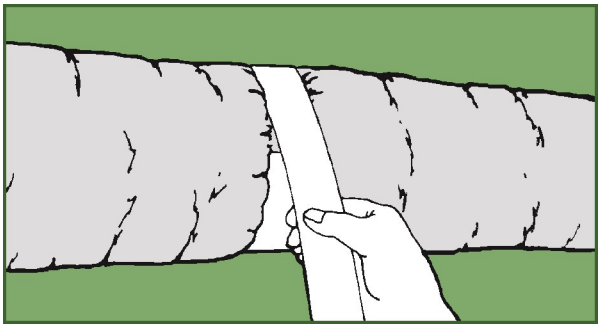
1. Fold back jacket and insulation from core. Butt two cores together on a 4" [100 mm] min. length metal sleeve.



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.



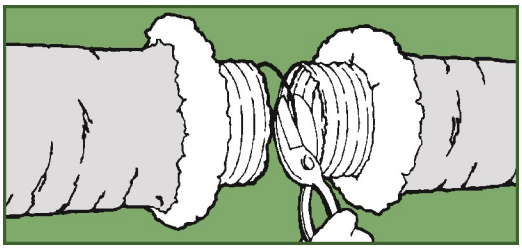
NOTES:

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.

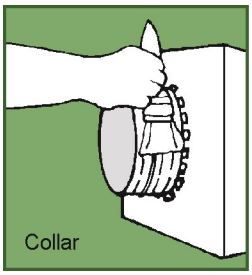
4.7.2 Alternate Installation Instructions for Air Ducts and Air Connectors - Nonmetallic with Plain Ends

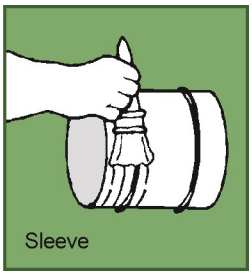
Connections and Splices - Using Mastic and Fasteners

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.

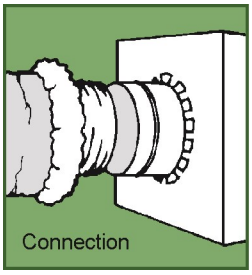


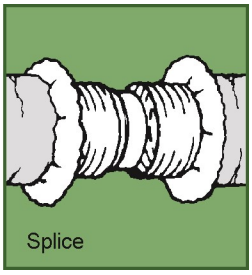
Step 2
Apply mastic approximately 2" [50 mm] wide uniformly around the collar of the metal fitting or over the ends of a 4" [100 mm] min. length metal sleeve. Reference data on mastic container for application rate, application thickness, cure times and handling information.



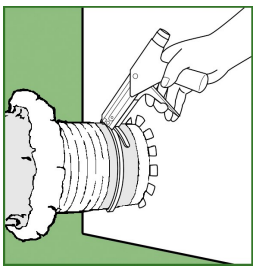


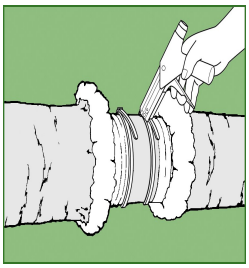
Step 3
Slide at least 2" [50 mm] of core over the fitting or sleeve ends and past the bead.



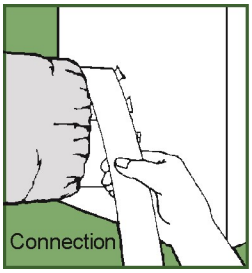


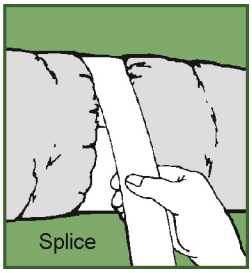
Step 4
Secure core to collar with a clamp applied past the bead. Secure cores to sleeve ends with 2 clamps applied past the beads.





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.



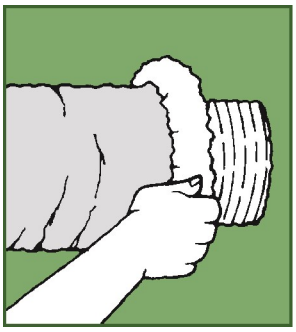


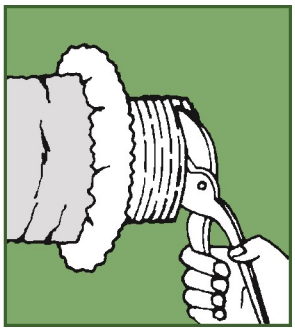
NOTES:
1. For uninsulated air ducts and air connectors, disregard references to insulation and jacket.
2. Use beaded sheet metal fittings and sleeves when using nonmetallic clamps.
3. Use mastics listed and labeled in accordance with Standard UL 181B and marked “181B-M” on container.
4. Use tapes listed 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.

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

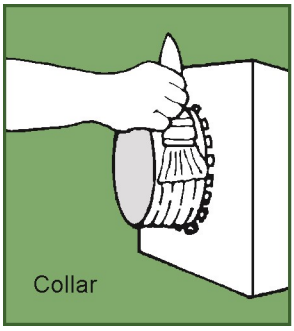
Connections and Splices - Using Tape or Mastic and Sheet Metal Screws

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.

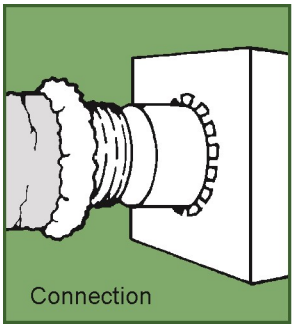


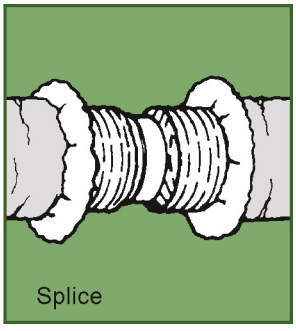


2. When mastics are required and for pressures 4" w.g. [1000 Pa] and over, seal joint with mastic applied uniformly to the outside surface of collar/sleeve. (Disregard this step when not using mastics and proceed to Step 3).

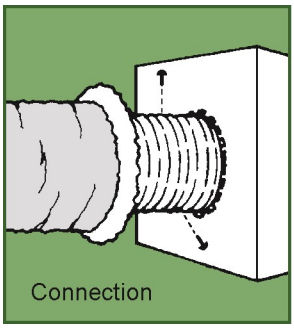


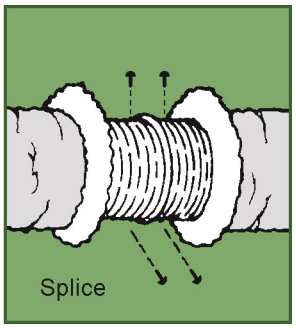
3. Slide at least 1" [25 mm] of core over metal collar for attaching duct to take off or over ends of a 4" [100 mm] metal sleeve for splicing 2 lengths of duct.



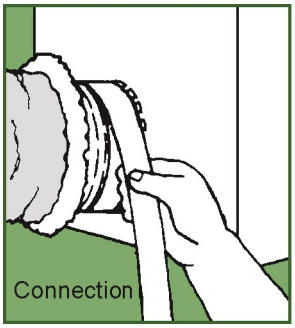


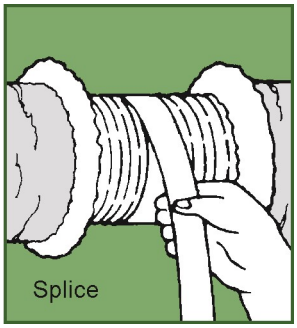
4. Secure to collar/sleeve using #8 sheet metal screws spaced equally around circumference. Use 3 screws for diameters under 12" [300 mm] and 5 screws for diameters 12" [300 mm] and over.



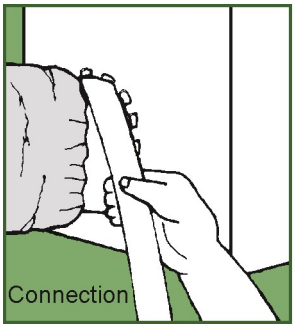


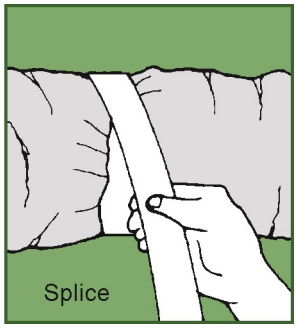
5. For pressures under 4" w.g. [1000 Pa] seal joint using 2 wraps of duct tape applied over screw heads and spirally lapping tape to collar/sleeve. (Disregard this step when using mastics per Step 2).





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".

4.8 Fittings, Fasteners & Sealants

4.8.1 Fittings

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 fitting 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.

4.8.2 Mastic

Mastic shall be listed and marked “UL181B-M”.

4.8.3 Tapes

Tape shall be listed and marked “UL181B-FX”.

4.8.4 Nonmetallic Fastener (Plastic ties)

Plastic ties often called zip ties shall be listed and marked “UL 181 B-C”.

Flexible duct secured with nonmetallic fasteners shall be limited to 6 inches W.G. [1500 Pa] positive pressure.

4.8.5 Metallic Fasteners

Metallic fasteners are not required to be listed.

4.8.6 Screws

ADC does not recommend the use of metal screws for making connections and splices with non-metallic flexible air ducts. Procedures and materials (tapes, mastic, fasteners) for connecting and splicing non-metallic flexible ducts are evaluated using UL181B Standard which does not address the use of metal screws. Potentially, metal screws can damage the components in some non-metallic flexible ducts.

ADC allows the use of sheet metal screws for making connections and splices with metallic flexible air ducts.

4.9 Typical Installation Locations

4.9.1 Ducts in Attics

When installing flexible ducting in attics, the ducts can be suspended from the rafters using an appropriate strap material and proper spacing. Flexible ducts can also rest on ceiling joists or truss supports provided the support centerline spacing does not exceed four (4) feet and the support surface is at least 1-1/2” in width. (Refer to Section 4.5 Supporting Flexible Ducts)

Avoid installing ducts in areas where exposure to direct sunlight will occur (e.g. turbine vents, sky lights canopy windows, etc.). As most flexible ducts are intended for Indoor Use Only, this exposure to UV radiation can lead to eventual deterioration of the outer vapor barrier. (Refer to 3.7 UV Light)

Avoid running ducts unnecessarily high up against the roof line. Attic spaces are generally significantly hotter closer to the roof line and this elevated temperature can significantly affect the energy efficiency of the duct system and potentially increase the occurrence of condensation.

4.9.2 Ducts in Crawl Spaces

In accordance with the building codes, ducts installed under a building structure shall not be in contact with the ground. All duct surfaces shall be at least 4" above the earth (i.e. not sitting directly on dirt, rocks etc.). In addition, the crawl space shall shield the ducting from environment exposure. For installations where the duct may be exposed, such as a mobile home crossover duct, only ducts designed and intended for use under exposed conditions shall be used.

Care must also be taken to ensure that the area under the structure is free from potential flooding. Flexible duct vapor barriers offer protection to the insulation from normal moisture vapor transfer; however, ducts sitting in standing water from flooding will deteriorate and not perform as designed.

4.9.3 Ducts in Walls and Between Floors

Flexible air ducts can be installed in walls and between floors. When installed vertically in walls the ducts shall be supported by straps at six (6) feet maximum intervals (Refer to Section 4.5 Supporting Flexible Ducts). For exterior walls refer to the appropriate energy code for the minimum insulation required between the ducts and the exterior space.

4.9.4 Ducts in Plenums

The building codes require that materials installed in plenums have a Flame Spread Index of 25 or less and a Smoke Developed Index of 50 or less when tested in accordance with ASTM E84. All listed and labeled Class 1 or Class 0 Flexible Air Ducts and Air Connectors meet this requirement and therefore may be installed within a plenum.

4.9.5 Ducts in Fire Resistant Rated Assemblies

Refer to Section 3.7 for materials allowed in Fire Resistant Rated Assemblies.

4.9.6 Ducts Exposed to the Elements

Unless specifically designed and labeled for outdoor use, flexible air ducts and air connectors shall not be used outdoors. Refer to the appropriate energy code for specific duct insulation requirements when ducts are installed outdoors.

4.10 Contact with Fixtures

4.10.1 Hot Equipment

Flexible air ducts shall be installed with a minimum clearance to an appliance as specified in the appliance manufacturer's installation instructions. They shall not be installed in contact with boilers, steam pipes, or other equipment that exceeds the duct manufacturer's maximum recommended use temperature.

4.10.2 Pipes

Contact with pipes, both metal and plastic, should be avoided when possible, but incidental contact with pipes should not cause damage to the flexible duct. Pipe manufactures instructions must be used to determine if contact with the flexible ducting will lead to degradation in the piping material.

4.11 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 0.5% of air volume when proper connections are made to the other systems.

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:

- Reference applicable industry manuals (SMACNA, NAIMA) for making round tap-ins into and sealing fitting joints to rigid ducts, plenums, etc.
- Make flexible duct connections/splices in accordance with the manufacture's recommended installation instructions for this Standard.
- Seal flexible duct connections with sealing materials listed and labeled to Standard UL 181B. Mechanically secure connections with approved clamping material.
- 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.

4.12 Condensation

In areas with high humidity, it is possible for condensation to form on flexible duct surfaces. Condensation will form when the temperature of any surface is lower than the dew point temperature of the surrounding air. This phenomenon is commonly observed on a glass of ice water placed in a warm, humid environment.

It is important to note that ducts with high R-value insulation can decrease the likelihood of condensation. For correct thermal performance, the duct needs to be exposed to ambient air on all sides without insulation compression.

To reduce condensation there are several installation practices to avoid when working in areas prone to condensation.

4.12.1 Practices to Avoid

4.12.1.1 Duct Contact

When ducts make contact, the temperature between the ducts could easily drop below the dew point temperature. (Figure 21)

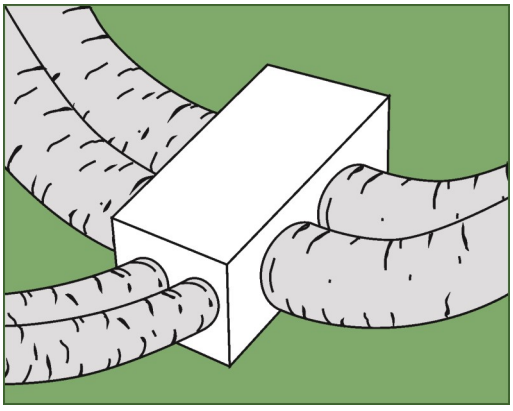


Figure 21

4.12.1.2 Insulation Compression

Compressing the thickness of duct insulation significantly impacts duct thermal performance resulting in surface condensation. Avoid compressing the duct insulation.

4.12.1.3 Insulation Contact

Avoid laying duct directly on attic insulation in areas conducive to condensation.. Ducts should be properly suspended to allow free circulation of ambient air around all surfaces of the duct. See section 4.5 for proper duct support.

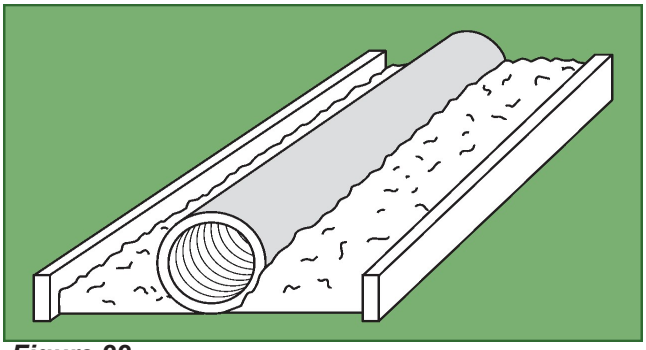


Figure 22

4.12.1.4 Adding External Insulation

Avoid adding extra insulation to the outside of the duct. Encapsulating or burying ducts that already contain an outer vapor barrier can potentially lead to moisture problems when the ducts are installed in areas of the country conducive to condensation. In addition, encapsulating flexible ducts may invalidate the manufacturers listing to the UL181 Standard and/or the warranty. Care should be taken when considering the practice of encapsulating or burying a flexible duct system in this manner.

4.12.1.5 Tight Strapping

Avoid installing duct supports too tightly this can lead to surface condensation.

4.12.1.6 Exposed Metal Fittings

Exposed metal fittings lead to condensation. All metal fittings should be insulated per the requirements in the building code.

4.12.1.7 Improper Sealed Inner Core

Avoid air leakage from flexible duct inner cores. Unconditioned air permeating the surround insulation leads to surface condensation.

4.12.1.8 Porous Inner Core

The use of porous inner liners should be avoided in areas conducive to condensation. (i.e. Perforated Acoustical Products)

4.12.1.9 Torn or Unsealed Vapor Barriers

Air infiltration through the exterior vapor barrier can result in condensation formation on the exterior of the inner liner.

4.13 Field Alterations

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.

4.14 Personal Protective Equipment

Insulated flexible air ducts generally contain fiberglass insulation and steel wire. Where necessary, wear eye protection, use a properly fitted approved respirator, and wear long-sleeve loose fitting clothing and gloves during installation.

CHAPTER 5: DUCT CARE

5.1 Duct Cleaning

Properly maintained HVAC systems with regular filter changes should not require cleaning.

The "cleaning" of all air duct types has become a common practice. This section addresses only the removal of dust and debris from the inside surface of flexible ducts "cleaning" can infer additional aspects.

Prior to “cleaning” the duct the owner should consider duct replacement, especially if the air distribution system is 15+ years old. Replacing a duct system with improved R-Value insulation requirements and much tighter installation methods should not only provide clean ducts but also provide lower future energy costs to operate the system.

If "cleaning" is preferred, its recommended to use a qualified technician that follows the procedures outlined by the National Air Duct Cleaners Association (NADCA) or another nationally recognized duct cleaning organization. The recommended “cleaning” method uses a rotating brush and vacuum process per NADCA. Flexible duct inner liners may be damaged by other overly aggressive contaminant removal techniques, such as high-pressure blow guns, air skipper, and air whips.

When the “cleaning” process is completed, any flexible duct connections that were opened must be properly resealed to maintain air tightness and duct thermal properties.

5.2 Duct Replacement

Properly installed, flexible duct should last the life of the dwelling. During this time however, the home may go through multiple HVAC unit replacements without upgrading the ducting. By ignoring the ducting, homeowners are missing a potential opportunity to improve system energy efficiency through duct sealing and R-Value improvement.

Flexible duct manufacturers continuously work toward increased energy improvements offering ducts with R-Value from R4.2 to R6 to R8. Replacing older, poorly-sealed, R-4.2 ducts with properly sealed R-6 or R-8 ducts can ensure the homeowner maximizes system efficiency and comfort.

5.3 Repairing Torn or Damaged Duct

Tears to flexible duct vapor barriers can be repaired using tape listed and labeled to UL 181B. Extensive damage may require replacement of the duct. It is not recommended to wrap ducts with a new vapor barrier as this can invalidate the product listing.

If the internal core is penetrated, damaged, or torn the ducting should be replaced or spliced per Section 4.7.

CHAPTER 6: ADC TEST STANDARDS

6.1 Performance Values

Table 1 lists the required tests and units of measurement and recommended values of minimum performance where applicable.

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 6.2.1- 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])	*Test - Section 6.2.2 - Friction Loss* 0.3 [2.5] (maximum)
	90° bend loss coefficient (C_o) @ R/D = 2	1.0 (maximum)
Acoustical (dB)	Sound Attenuation Sound Generation Radiated Noise	*Test - Section 6.2.3 - 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 6.2.4- 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 6.2.5 - Duct Leakage* 0.03 [1.7 x 10^{-4}]
Leakage *Connections) All diameters*	cu.ft./hr. [L/s]	*Test - Section 6.2.5 - Duct Leakage (Including* 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 6.4.1* *Water Vapor Transmission Rates of Vapor Barriers* 1.0 [57.5] (maximum)

** Not applicable to uninsulated ducts.*

6.2 Performance Requirements

6.2.1 Thermal Performance.

Thermal loss properties of insulated flexible duct shall be based on flat sections of insulation only at installed duct wall thickness. Ratings shall exclude air film resistance, vapor retarders, or other duct components.

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

Where: R = Thermal resistance (hr-ft^2 - °F/Btu) [(m^2·°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-ft^2 - °F) [W/(m·°C)]

The insulation 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 notes 1 and 2 below).

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

The jacket layflat width can be determined by circumferentially cutting the jacket, removing it from the duct, laying it on a flat surface, and then 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*.

6.2.2 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 diameter range. Friction loss in 90° bends shall be presented in graphical form at three different bend radii.

6.2.2.1 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 Section 6.1, a 12" [300mm] nominal internal duct size, tested at 1000 fpm [5.1 m/s] velocity shall be used.

6.2.2.2 90° Bends.

Friction loss coefficient (C_o) 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 Section 6.1, 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.

6.2.3 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:

6.2.3.1 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.

6.2.3.2 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.

6.2.3.3 Radiated Noise

Radiated noise reduction shall be reported with 0 air flow and at one flow of 2500 fpm [12.7 m/z] 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, 200 and 4000 hertz.

6.2.4 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 Section 6.1, 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.

6.2.5 Duct Leakage

Duct leakage shall be determined in accordance with ADC Test Code FD 72-R1 or UL 181 Standard. Leakage for ducts that includes fittings and connections shall be listed in accordance with the UL 181 Standard. 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].

6.3 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.

6.3.1 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 6.4.1

6.3.2 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 6.4.2

6.3.3 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 based on the quality control records, no further sampling is required.

6.4 Methods of Test

6.4.1 Water Vapor Transmission Rates of Vapor Barriers

The water vapor transmission rate of the vapor barriers shall be determined in accordance with either ASTM E96 Procedure A or ASTM F1249. 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. [300mm x 300mm] shall be cut from each at the approximate center of the sample duct.

WVTR specimens will then be prepared and tested in accordance with the procedures outlined in either ASTM E96 Procedure A or ASTM F1249.

The permeance of the material shall be reported as the average of three determinations tested. The results are to be reported in U.S. perms [ng/s•m^2•Pa)].

6.4.2 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 reference 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.

6.5 Product Marking

6.5.1 Listing Mark and Label Information

All ducts shall be marked, labeled or printed at a maximum interval of 10 ft. [3.0m] or a fraction thereof. Labels shall contain at least the following information.

- Identifying mark of the listing agency
- Manufacturer's identification
- Maximum Positive and Negative Pressure Rating
- Maximum Rated Velocity
- R-Value (applicable to insulated ducts only)
- Classification of Surface Burning Characteristics (Class 0 or 1)
- Identification as either an Air Duct or Air Connector

6.5.2 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.

6.6 Product Certification

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

6.6.1 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".

6.7 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 other specified, each container shall be marked with the following information:

- Manufacturer or Brand Name
- Product Designation Product Name (Optional)
- Size (internal diameter)
- Nominal Length of Duct Section
- Number of Sections per Container
- Storage and/or Stocking Instructions (if any)
- Production date or date code of the manufacturer.

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

CHAPTER 7: REFERENCE STANDARDS

7.1 Documents Referenced in this Standard

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 Duct and Fittings

ASHRAE Handbook – Fundamentals and Equipment Volumes

ASTM E84 – Test for Surface Burning Characteristics of Building Materials

ASTM E96 – Water Vapor Transmission of Material in Sheet Form

ASTM F1249 – Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor

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 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 Standard

SMACNA – HVAC Duct Construction Standards, Metal and Flexible

UL Heating, Cooling, Ventilating and Cooking Equipment Directory

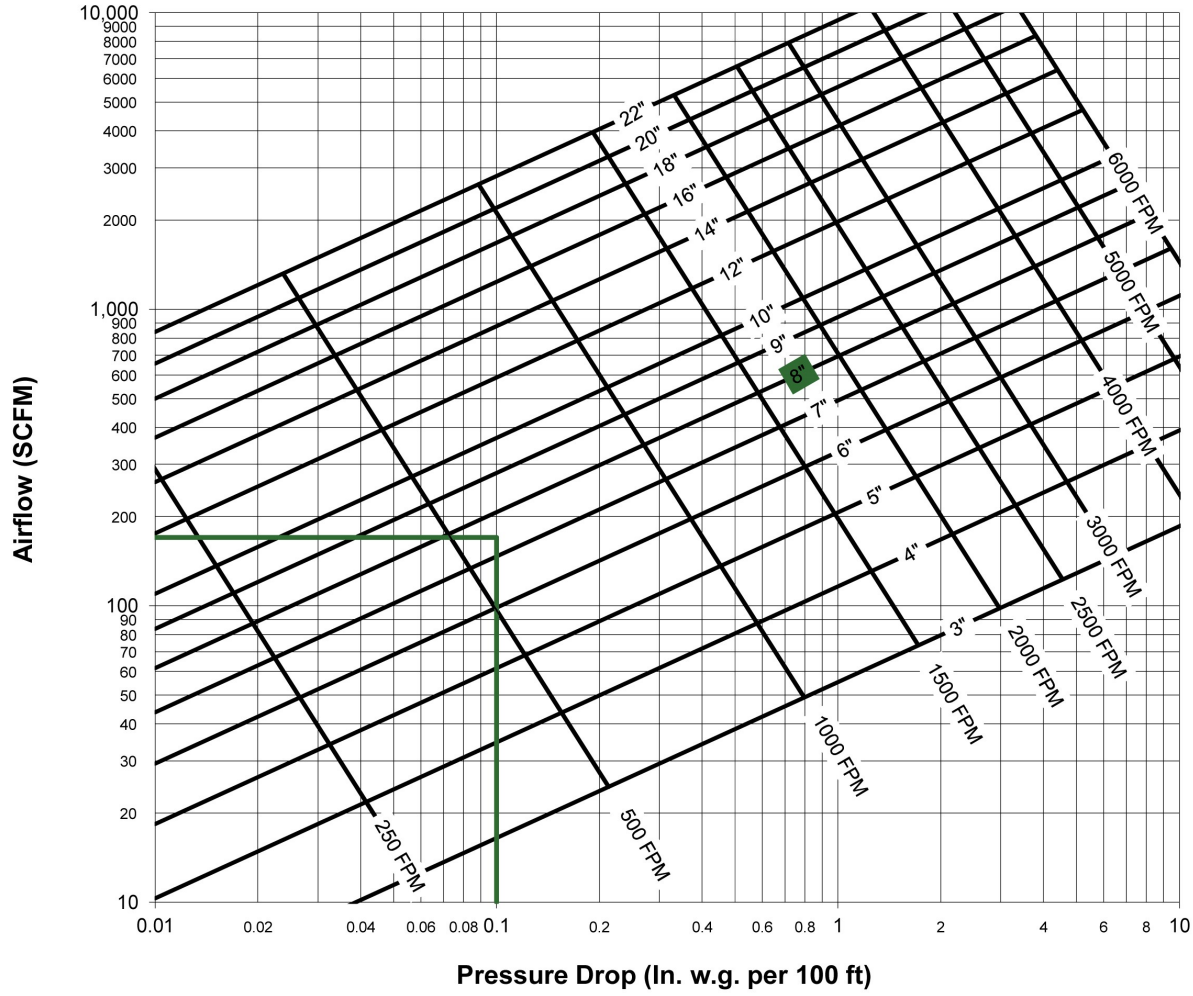
UL Standard 181 – Factory-Made Air Ducts and Air Connectors

UL Standard 181B – Closure System for Use With Flexible Air Ducts and Air Connectors

UL Standard 723 – Tests for Surface Burning Characteristics of Building Materials.

APPENDIX A

Reference Pressure Drop Chart



Example Design Requirements:

Design Friction Rate – 0.1 IWC/100'

170 CFM

Duct selection is then based on the intersection of the green lines in the graph above. The intersection occurs between 7" and 8" duct, approximately a 7.5" duct. The size is rounded upward to meet the final selection of 8".

NOTE: When using a friction chart or duct slide rule ensure that you are using the manufacturers provided slide rule. Slight variations in design and manufacturing can cause the friction numbers to vary between manufactures. If no data is available, use the generic flexible duct friction loss chart in ACCA Manual D. NEVER use a sheet metal friction chart or duct slide rule when sizing a duct. The walls of sheet metal are smoother than flexible ducting which means the friction amounts will differ significantly. Using a sheet metal friction chart will result in an incorrectly sized HVAC duct system.

APPENDIX B

UL 181 TEST SECTIONS

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

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.

APPENDIX C

TYPICAL DUCT TYPES

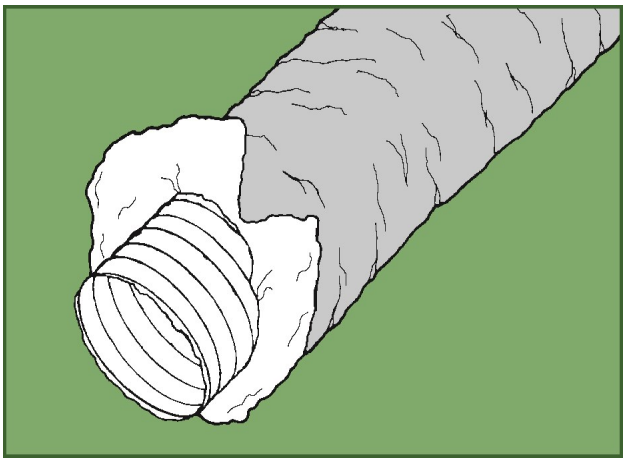


Figure 23 *Nonmetallic, Insulated, Lined (Non porous Inner Core)*

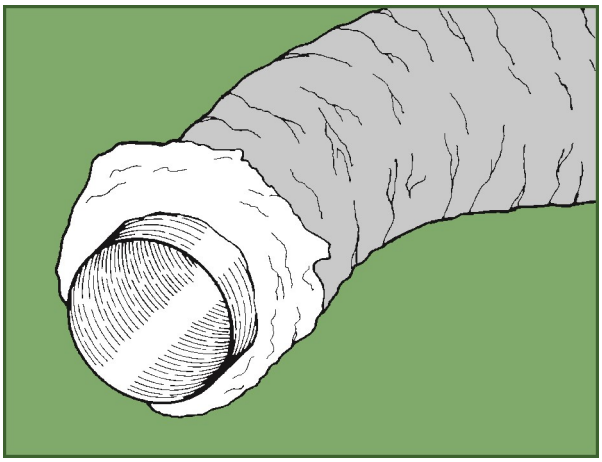


Figure 24 *Metallic, Insulated*

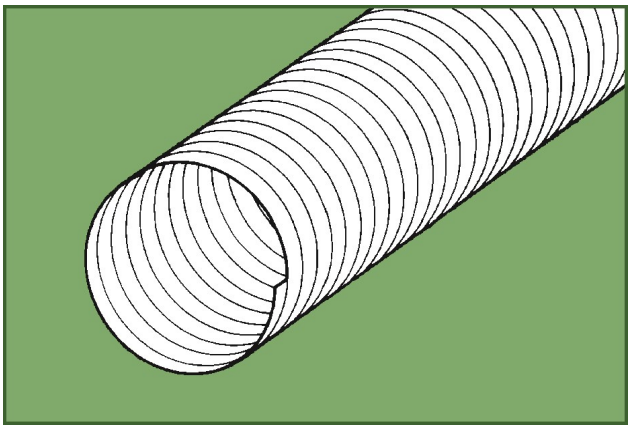


Figure 25 *Nonmetallic, Uninsulated*

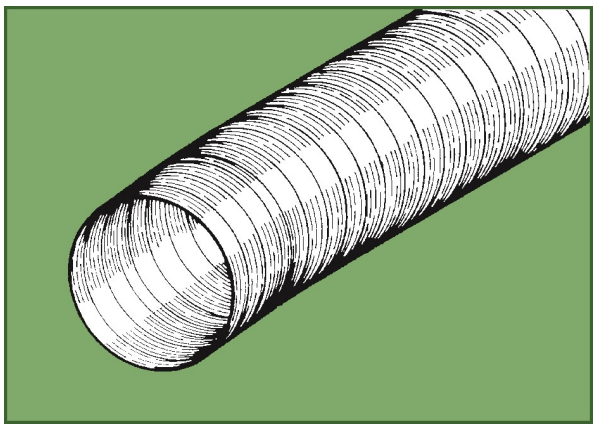


Figure 26 *Metallic, Uninsulated*

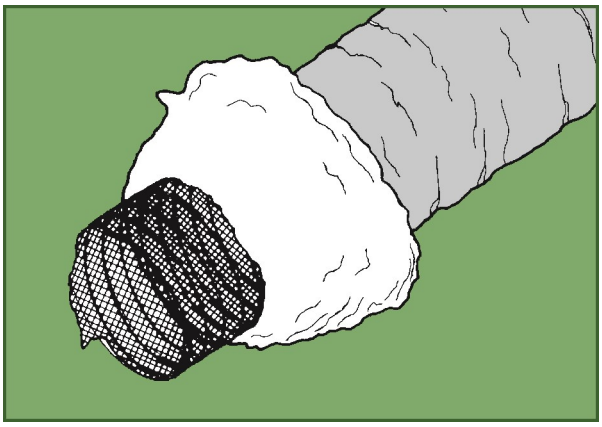


Figure 27 *Nonmetallic Insulated, Perforated (Porous Inner Core)*

APPENDIX D

TYPICAL DUCT ACCESSORIES

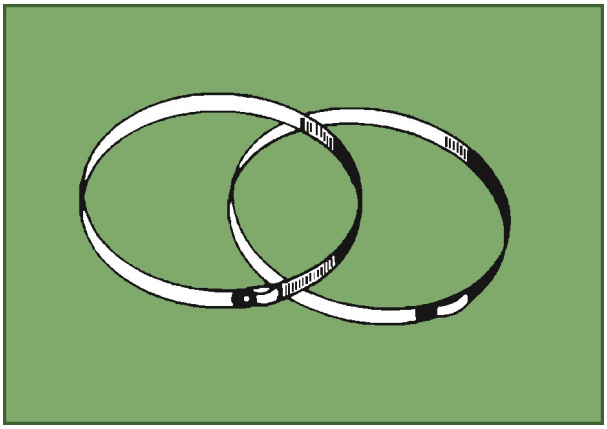


Figure 28

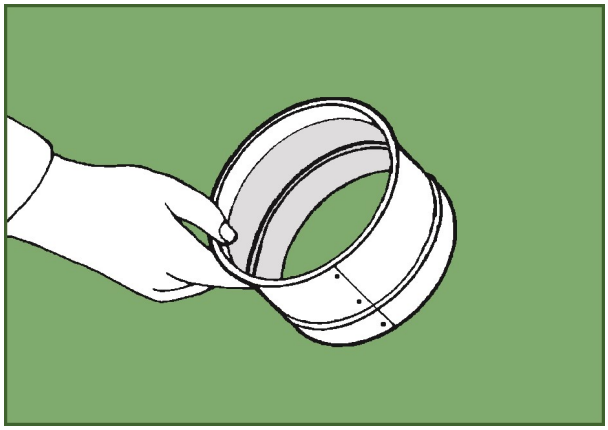


Figure 29

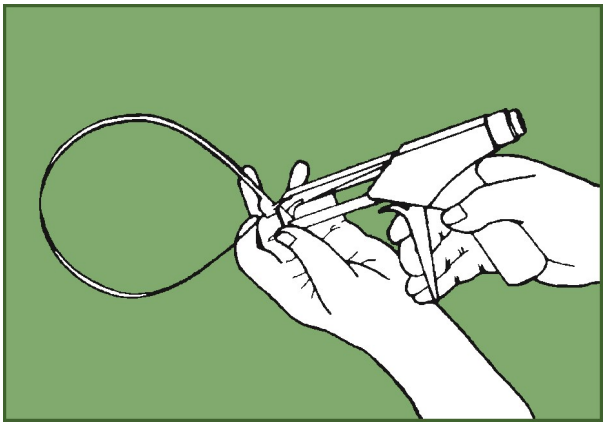


Figure 30

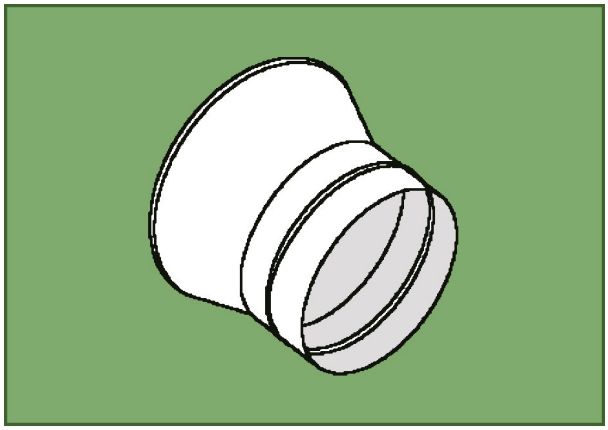


Figure 31

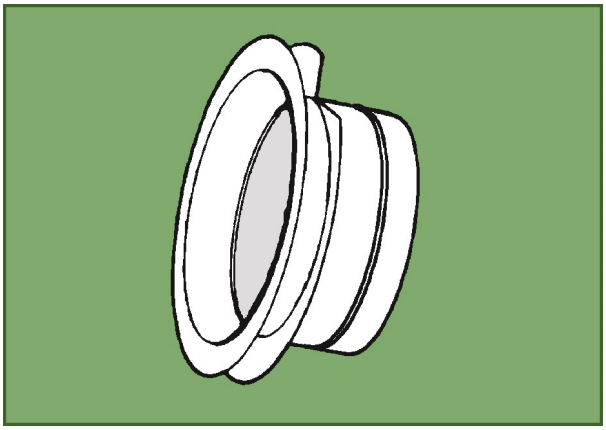


Figure 32

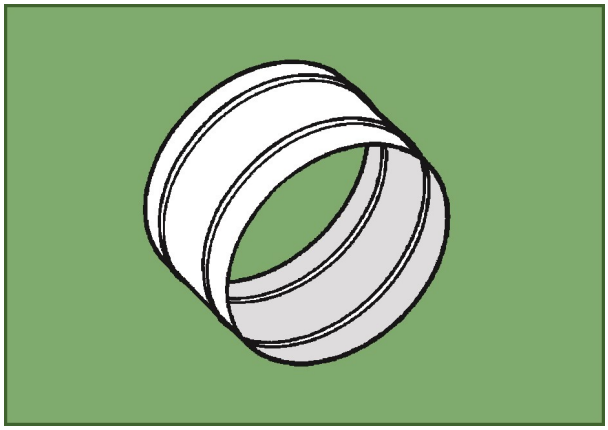


Figure 33

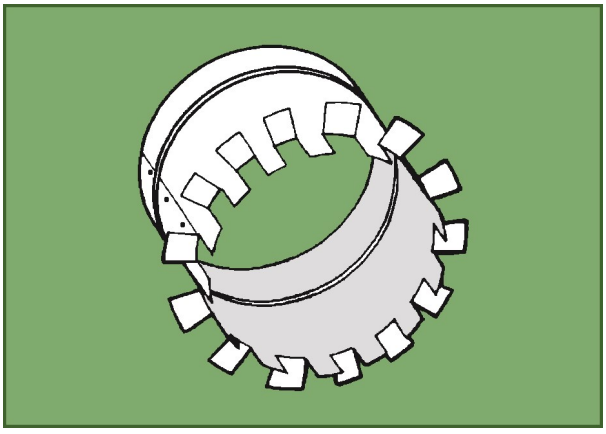


Figure 34

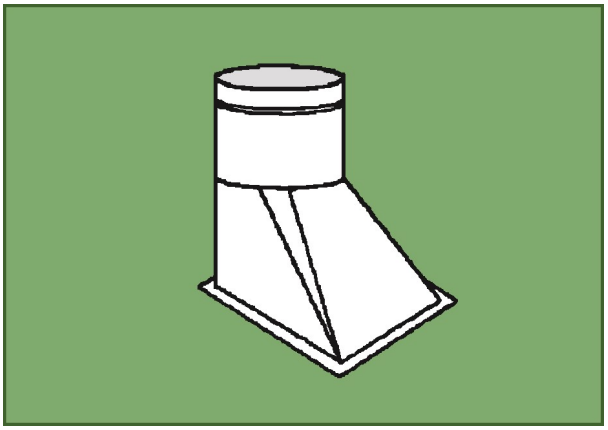


Figure 35

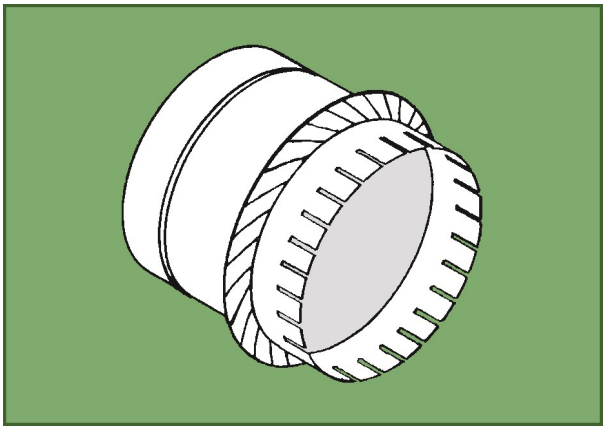


Figure 36

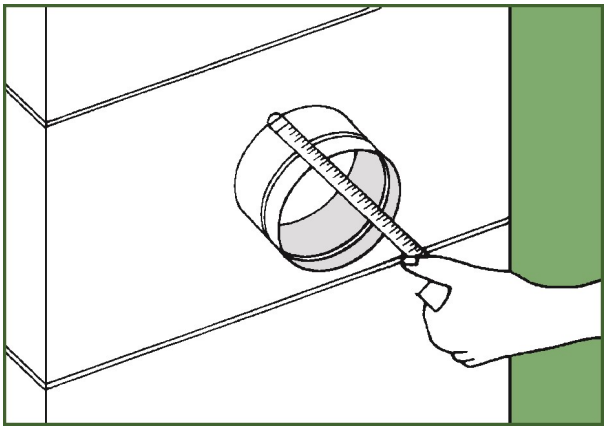


Figure 37

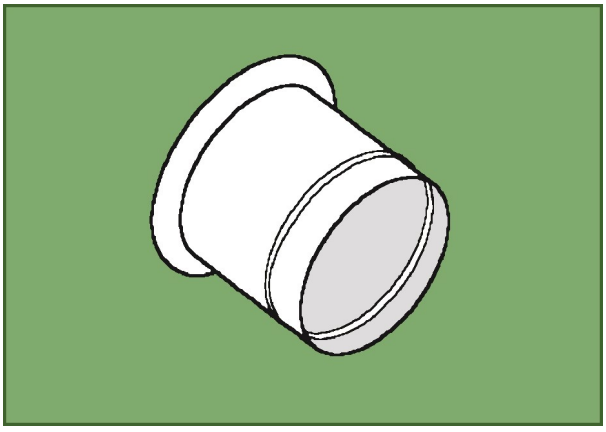


Figure 38

APPENDIX E

Flexible Duct Installation Checklist

- ☐ **Horizontal runs are supported at 4' maximum intervals (Section 4.5)**
- ☐ **Vertical risers are supported at 6' maximum intervals (Section 4.5)**
- ☐ **All duct supporting material is at least 1.5" wide at point of contact with the duct surface. (Section 4.5)**
- ☐ **All plastic clamps used are listed & labeled per UL181 and marked Ul 181B-C (Listing found on clamp bags)**
- ☐ **All tape used to seal was listed & labeled per UL 181 and marked UL 181 B-FX (Listing found on the tape)**
- ☐ **All mastic used to seal was listed & labeled per UL 181 and marked UL 181 B -FX (Listing found on mastic container)**
- ☐ **Ducts are installed fully extended (Section 4.4 & Section 4.6)**
- ☐ **Duct bends are at least one duct diameter bend radius (Section 4.3)**
- ☐ **Duct inner core is installed at least 1 inch onto collars and past the bead prior to the application of the tape or mechanical fastener. (Section 4.7)**
- ☐ **Duct outer vapor barrier is secured using two wraps of Listed Tape where required by the building codes. (Section 4.7)**
- ☐ **Duct is not crimped tightly against any other objects. (Section 4.3)**
- ☐ **Duct is not exposed to weather or UV light (Unless otherwise specified by the manufacturer) (Section 3.7)**
- ☐ **Contact with other ducts or fixtures is minimized to prevent condensation (Section 4.12)**
- ☐ **Air Connectors do not exceed 14 feet in length (Section 3.1.2)**

NOTES

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