

# Characteristics, Testing, & Classification of Flexible Air Ducts & Air Connectors

Presented to

**ASHRAE TC 5.2 Technical Committee**

Summer Meeting 2014

# Flexible Duct Types

Flexible Air Ducts and Air Connectors are described in two “types” –

## Non-Metallic and Metallic

Typical “non-metallic” ducts –



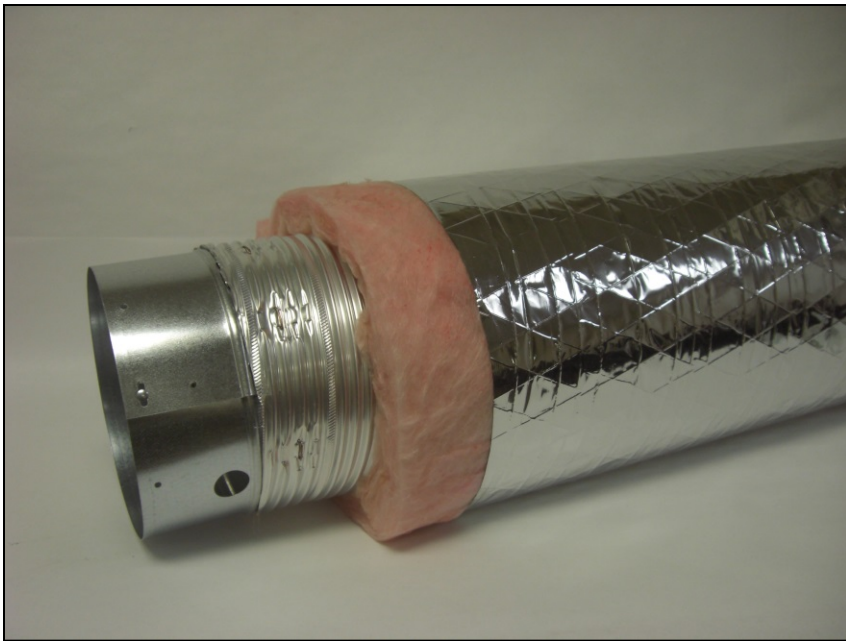
Insulated



Non-Insulated

## Flexible Duct Types (Cont.)

Typical “metallic” ducts –



Insulated



Non-Insulated

# Flexible Duct Classification

Flexible ducts are classified by their performance when tested to the UL181 Standard for Safety Factory-made Air Ducts and Air Connectors.

The UL181 Standard consists of seventeen (17) tests -

## **Fire Testing:**

Surface Burning  
Flame Penetration  
Small-Scale Burning  
Flame Resistance

## **Physical:**

Mold Growth & Humidity  
Corrosion  
Temperature Aging

## **Performance:**

Positive Pressure  
Collapse (Negative Press.)  
Leakage  
Tension  
Torsion  
Bending  
Impact  
Static Load  
Puncture  
Erosion

# Flexible Duct Classification (Cont.)

Classification is broken down into two “classes” –

## Class 0 or Class 1

- **Class 0**

In order to achieve “Class 0”, the duct must have a Flame Spread Value equal to 0 and a Smoke Developed Index equal to 0 when tested to the Surface Burning Characteristics test (UL723, ASTM E-84).

All other remaining applicable tests of the UL181 Standard are performed.

- **Class 1**

In order to achieve “Class 1”, the duct must have a Flame Spread Value equal to or less than 25 and a Smoke Developed Index equal to or less than 50 when tested to the Surface Burning Characteristics test (UL723, ASTM E-84).

All other remaining applicable tests of the UL181 Standard are performed.

# Flexible Duct Categories

Flexible Ducts are broken down further into two “categories” –

## Air Ducts and Air Connectors

- **Air Ducts**

An “Air Duct” must successfully pass all of the seventeen tests in the UL181 Standard.

- **Air Connectors**

An “Air Connector” is not tested to three of the seventeen tests in the UL181 Standard that Air Ducts must pass - Flame Penetration, Puncture, and Impact tests.

# How To Identify the Duct Category by the Listing Label

## Air Ducts:

Identified by a Square or Rectangular shaped UL Label with the words “Listed” and “Air Duct”.

These products do not have length limitations per UL181, NFPA, and the building codes.



## Air Connectors:

Identified by a Round Shaped UL Label with the words “Listed” and Connector”.

The label also indicates these products are “For Installation in lengths not over 14 feet”



# How To Identify the Duct Category by the Listing Label (Cont.)

Air Ducts and Air Connectors can be found in both insulated and non-insulated types however the most common “Air Ducts” are insulated and the most common “Air Connectors” are non-insulated.

That being said –

- Insulated “Air Connectors” find some use in the markets in Canada.
- There are also some non-insulated “Air Ducts” being sold in the US & Canada.

The category of Air Duct or Air Connector is based on the ducts performance when tested to the UL181 Standard and not on the construction or type, and insulated or not. You must review the products listing and its label to determine if it is an “Air Duct” or an “Air Connector”.



# Testing of Flexible Ducts

## Surface Burn Characteristics:

Tested in the Steiner Tunnel to UL723 or ASTM E-84. Full 25 feet length ducts are cut along the entire length, flattened out, and burned on the roof of the furnace for a period of 10 minutes. Three samples are tested for both the inner and outer surface of the duct. A flame spread value and smoke developed index is determined for each duct surface.

## Flame Penetration:

A 2' x 2' flattened section of duct wall is placed on top of a flame furnace that has been preheated to 1625°F for 2 hours. The flattened duct sample forms the top of the furnace with the exterior side of the duct sample exposed to the flame. An 8 pound weight with a bearing surface of 1" x 4" is placed at the center of the sample between the wire helix pushing the sample surface deeper into the furnace flame. The sample must withstand the weight without collapse or flame penetration for a period of 30 minutes. # samples are tested. **Air Connectors are not tested for flame penetration.**

## Small-Scale Burning:

Six 3' long samples of duct are testing using a controlled 2-1/2" high propane flame with 60 second exposure while held in a stationary frame. Samples are tested in a horizontal, 45°, and vertical position. The exterior and interior surfaces are burned in all three positions. Flaming and glowing must self-extinguish within 60 seconds from time of flame withdrawal.

## Flame Resistance:

Test applicable only to fabrics, tapes, or other joining materials when, as applied to an air duct or air connector, the material is exposed to the internal air stream.

# Testing of Flexible Ducts (Cont.)

## **Mold Growth & Humidity:**

Mold mycelia and spores are applied to 4'' x 4'' samples of duct cross-section. The samples are placed in a closed vessel in which an atmosphere saturated with water vapor is maintained at room temperature and under dark conditions for a period not less than 60 days. The samples are examined visually for extent of mold growth and for indications of deterioration.

## **Corrosion:**

Metals used in the construction of air ducts and air connectors shall be resistant to atmospheric corrosion. All steel used in flexible duct shall be coated with 0.3 oz/sq.ft. or demonstrate equivalency to equivalent zinc-coated steel when tested in the salt spray fog chamber operated per ASTM B117.

## **Temperature Aging:**

Flexible Air Ducts and Air Connectors are to be exposed to hot and cold temperature aging. 8'' x 8'' square samples from duct cross-sections are placed in a closed vessel in which an atmosphere saturated with water vapor is maintained at room temperature for a period of 48 hours. The samples then are removed and immediately placed in a refrigerated compartment and maintained at a temperature of 0°F for a period of 24 hours and then inspected for damage. Two 3 feet long sections of Air Duct or Air Connector is placed in a chamber which supplies 265°F to the interior of the duct and 125°F to the exterior of the duct simultaneously for a period of 60 days.

# Testing of Flexible Ducts (Cont.)

## **Positive Pressure:**

Air Ducts and Air Connectors must withstand an internal positive air pressure equal to 2-1/2 times the rated positive pressure without rupture. Test samples shall be 8 feet long with each end attached to a stationary fixture. The test pressure is maintained for a period of 1 hour.

## **Collapse (Negative Pressure):**

Air Ducts and Air Connectors must withstand an internal negative air pressure equal to 2-1/2 times the rated negative pressure without reduction in either external or internal cross-sectional area exceeding 20 percent at any time during the test. Test samples shall be 8 feet long with each end attached to a stationary fixture. The test pressure is maintained for a period of 1 hour.

## **Leakage:**

Air Ducts and Air Connectors must not leak greater than 20 times the sample volume when tested at an air pressure of 0.50-inch water column maintained for a period of 1 hour. Test samples shall be 8 feet long with each end attached to a stationary fixture. The test pressure is maintained for a period of 1 hour.

# Testing of Flexible Ducts (Cont.)

## **Tension:**

Air Ducts and Air Connectors shall not be damaged when subjected to a vertical 25-pound force. Test samples shall be 8 feet long with one end attached to a stationary fixture and the other to the test load. The test load is maintained for a period of 24 hours.

## **Torsion:**

Air Ducts and Air Connectors shall not be damaged when subjected to a torque of 25 foot pounds or a torque capable of producing an angular rotation of 180 degrees, whichever occurs first. Test samples shall be 8 feet long and fixed to one stationary collar and one collar allowed to rotate. The torque is first applied clockwise and then again counter-clockwise. The sequence is repeated five times each direction. The sample shall not rupture, break, tear, rip, collapse, or separate.

## **Bending:**

Air Ducts and Air Connectors shall not be damaged when bent through a 180-degree arc over a mandrel having a diameter equal to the inside diameter. Test samples shall be 8 feet long and held in place against a test mandrel equal to one duct diameter. The sample is to be bent through a 180-degree arc around the test mandrel and then returned straight. The bend is repeated five times. The sample shall not rupture, break, tear, rip, collapse, or separate.

# Testing of Flexible Ducts (Cont.)

## **Impact:**

Air Ducts shall withstand impact from a 15 pound formed sand bag when dropped from a height of 10 inches above the sample test. Three test samples 8 feet long shall be tested. The sample shall not deform at the point of impact greater than 20 percent of the original cross-sectional area. Three samples shall be averaged with no single sample exceeding 25 percent of cross-sectional area. **Air Connectors are not tested for impact resistance.**

## **Static Load:**

Air Ducts and Air Connectors that incorporate integrated methods of field support shall support a load equal to 2-1/2 times the weight of an eight foot test sample. The load shall be applied uniformly across the length of the sample. When possible, the load is to be applied by laying rods on the inside of the duct. The load shall remain for a period of 24 hours.

## **Puncture:**

Air Ducts shall not be punctured by free fall of a 3/8" diameter steel rod with a 9/16" diameter impact head. The plunger assembly shall have a total weight of 2 pounds. The plunger shall be dropped from a height of 20 inches above the sample impacting the sample at each 120 degree point around the circumference. **Air Connectors are not tested for puncture resistance.**

# Testing of Flexible Ducts (Cont.)

## **Erosion:**

Air Ducts and Air Connectors shall not crack, peel, flake off, or show evidence of delamination or erosion when air is passed through at a velocity equal to 2-1/2 times the rated velocity or 2500 FPM, whichever is lower. The test sample shall include a 90 degree bend equal to one duct diameter bend radius. Air shall pass through the test sample and any eroded particles shall be collected on a mesh screen made from a double layer of cheesecloth (14 to 15 square yards per pound) with an area not less than five times the inside cross-sectional area of the test sample and located 1 foot from the outlet end of the test sample. Air is to be passed through the sample at test velocity with the collecting screen removed for a period of at least 1 hour and not more than 24 hours. The collection screen then is to be placed in position. The test then is to proceed at test velocity and continued for a period of 4 hours. The collecting screen is examined for macroscopic particles at the end of each hour during the test period.

# Another Flexible Duct Type

One other type of flexible duct that is available –

## **Clothes Dryer Transition Duct**

A Clothes Dryer Transition Duct is investigated and classified per UL Standard 2158A. UL2158A uses some of the test requirements from the UL181 standard to evaluate ducts used for venting commercial and residential clothes dryers. The following tests are applicable –

Surface Burn

Flame Resistance

Bending

Corrosion

Puncture

Impact

Tension

Torsion

Clothes dryer Transition Ducts are limited to 8 feet maximum produced and installed length and are intended to be used to connect the dryer to the stationary building outlet only.

# ADC

## *Flexible Duct Performance & Installation Standards (5<sup>th</sup> Edition)*

### *The “Greenbook” of Flex*

Provides information about –

*Characteristics of flexible duct*

*Testing, Listing, Reporting, and  
Certifying*

*Installation Requirements*

*Typical Accessories*

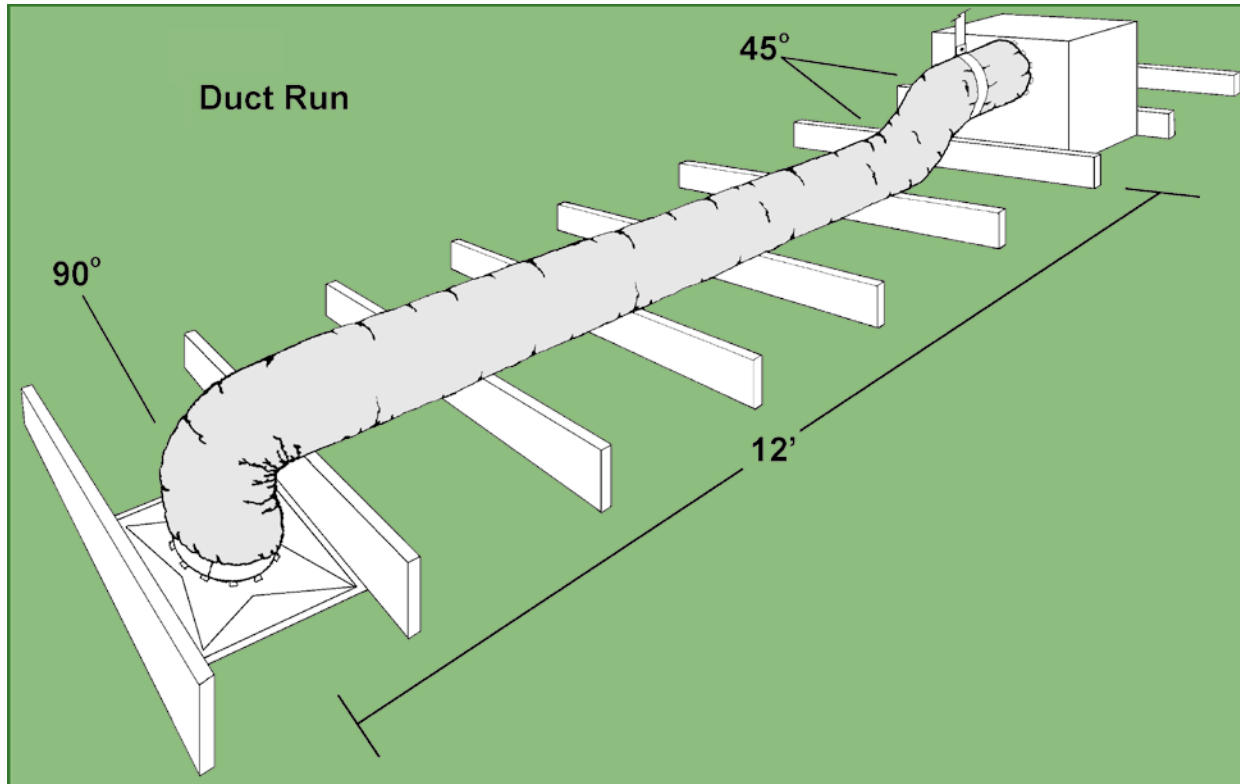
*General Commentary*





## ADC Guidance on Sizing Flex Runs

The total equivalent length (EL) for the duct run is the sum of the entrance/exit EL's, the bend EL's, and the length of the duct used.



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.
<hr/>	
Total Equivalent Length =	124 ft.



## Representative Laboratory Demo (Supply Only)



Representative residential up-flow supply system for an approximate 1100 ft<sup>2</sup> house sized following the procedures in ACCA Manual D and using the flex sizing chart. Actual air delivery was measured using an ALNOR Balometer.

## Duct Sizing for Laboratory Demo

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<u>Designation</u>	<u>Duct Length</u>	<u>Duct Size</u>	<u>Design CFM</u>	<u>Measured CFM *</u>
Trunk A	8	8	---	---
Trunk B	9	11	---	---
Trunk C	6	7	---	---
Trunk D	4	7	---	---
Branch 1	4	6	144	128
Branch 2	3	5	110	100
Branch 3	5	7	152	150
Branch 4	4	6	144	123
Branch 5	2	3	30	29
Branch 6	7	3	30	28
Branch 7	9	7	163	140
Branch 8	9	5	100	100
Branch 9	3	4	75	79
<b>Total -</b>			<b>948</b>	<b>877</b>

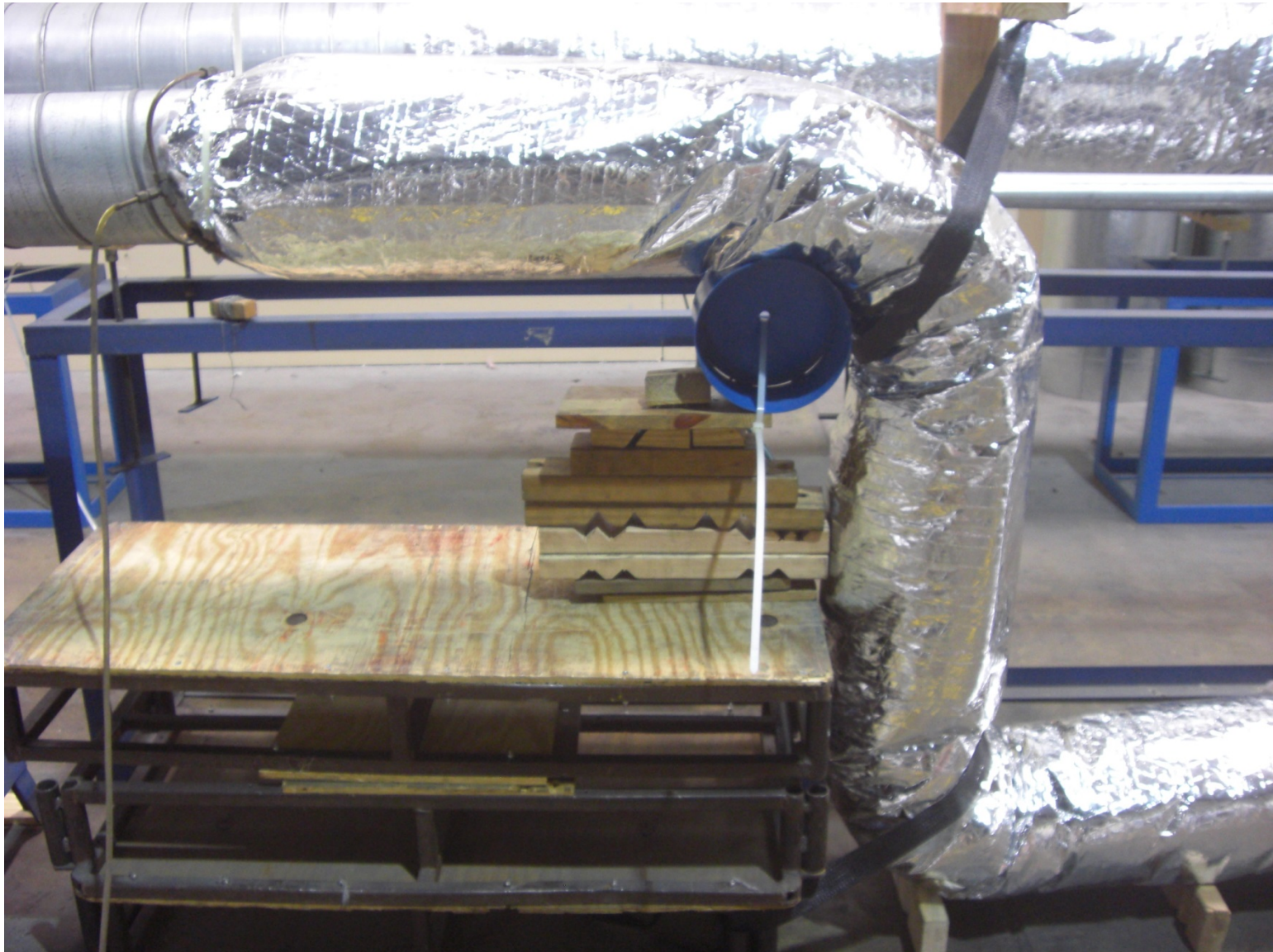
\* Measured with ALNOR Balometer

**-7%**

# Pressure Drop Testing of 8" Flex Run (100 Equiv. Ft.)



## Pressure Drop Testing of 8" Flex Run (1xD Bends)



# Pressure Drop Testing of 8" Flex Run (Sharp Bends)

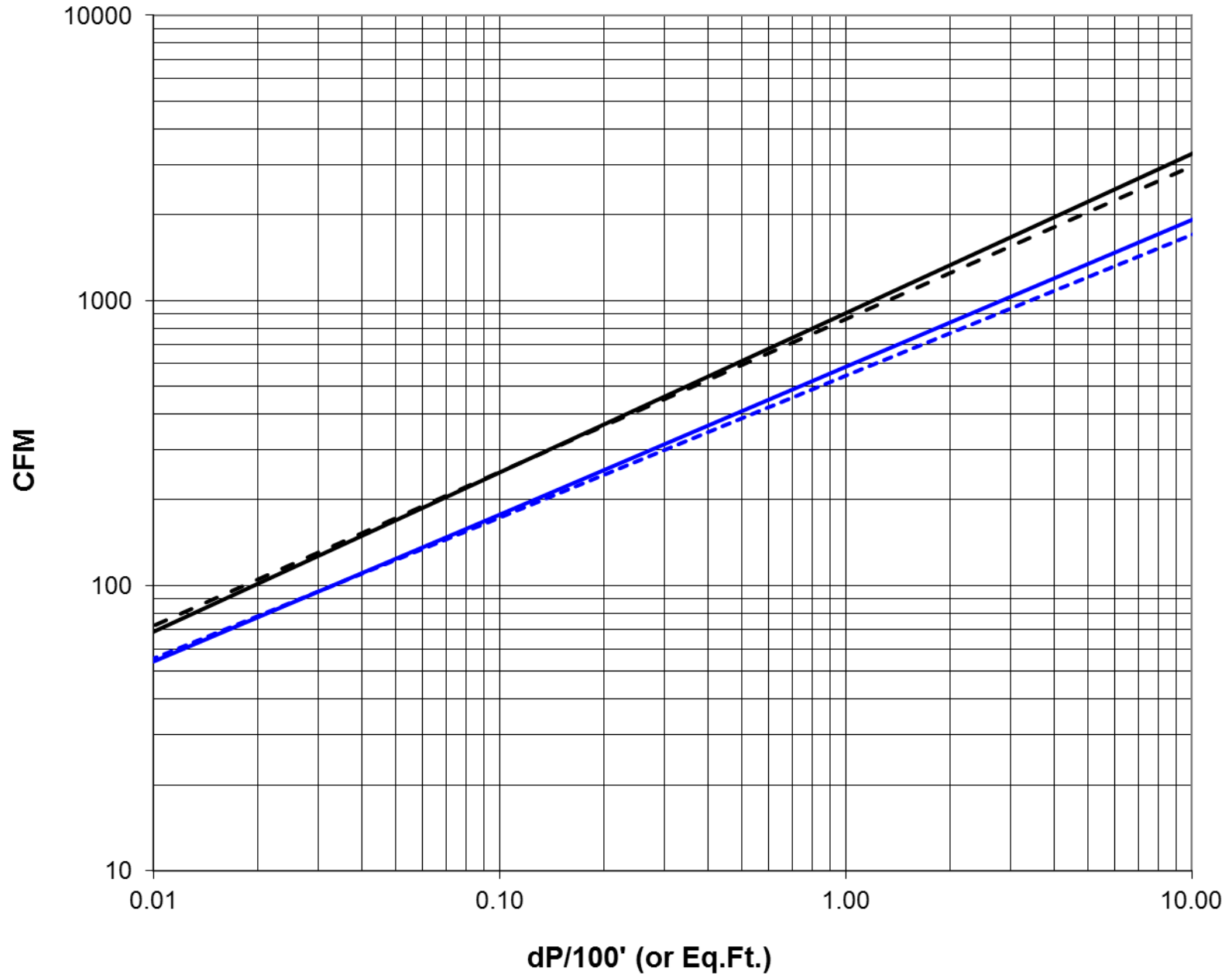


# Pressure Drop Testing of 8" Metal Run (100 Equiv. Ft.)



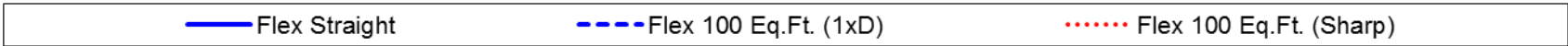
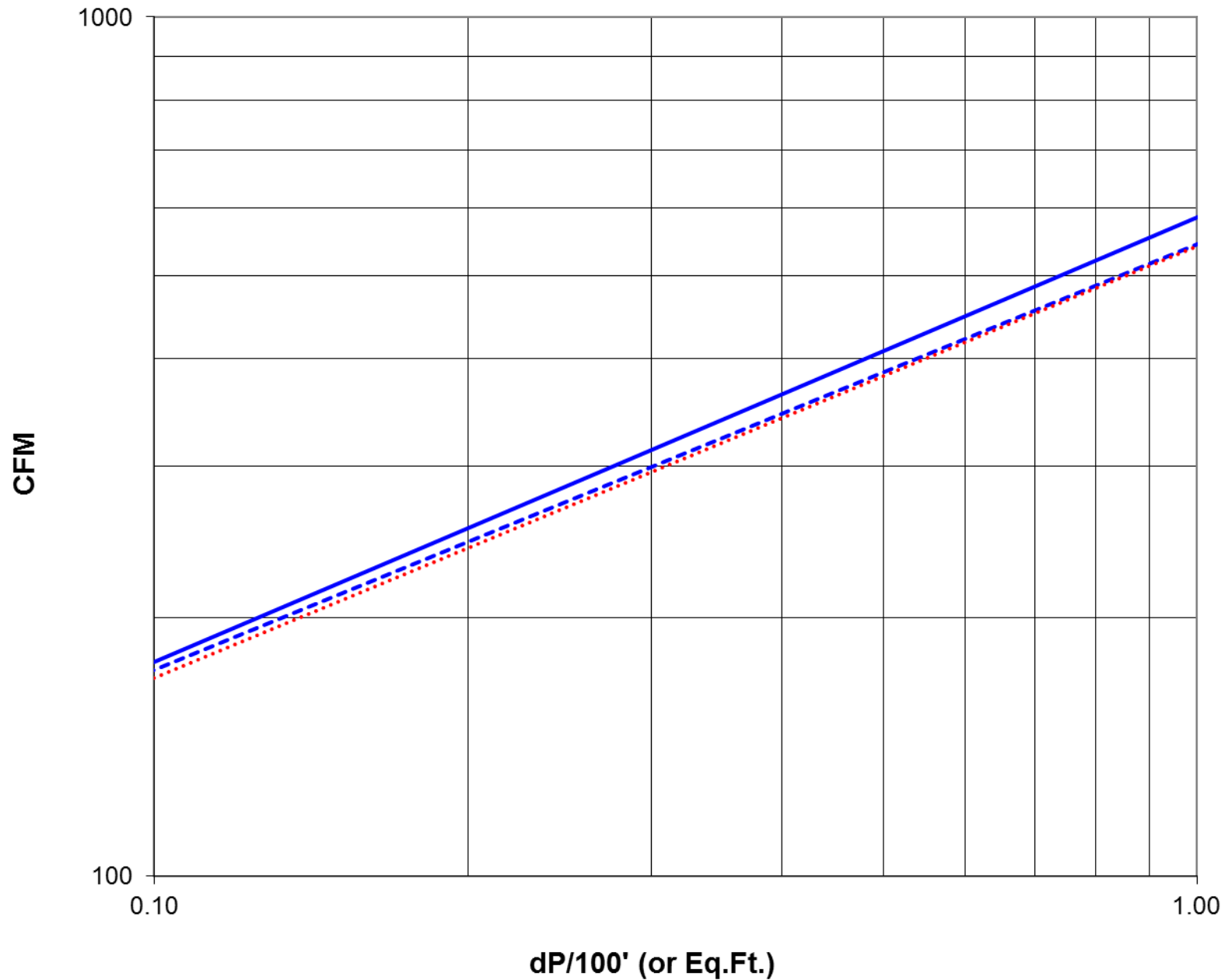


# 8" Metal & Flex (Straight & Bends at 100 Eq.Ft.)



— Metal Straight    - - Metal 100 Eq.Ft.    — Flex Straight    - - Flex 100 Eq.Ft.

# 8" Flex, Straight & Bends at 100 Eq.Ft. (1xD & Sharp)



# Flex Duct Installation Guidelines

## Key Points from ADC “Greenbook”

- Design the flexible duct system per the requirements of ACCA Manual D.
- Use the flexible duct manufacturer’s air friction loss data to size the ducts whenever possible, otherwise use the chart in ACCA Manual D.
- Use the minimum length of flexible ducting needed to make the connections (Install fully extended).
- Keep bends greater than or equal to 1 duct diameter. Minimize sagging and “snaking” of the duct runs.
- Properly seal the flexible duct connections.
- Properly support the flexible ducting.

# Codes & Standards

UL181 Standard for Safety, Factory-Made Air Ducts & Air Connectors

UL2158A Investigation for Clothes Dryer Transition Ducts

SMACNA HVAC Duct Construction Standard, Metal & Flexible

NAIMA Fibrous Glass Duct Construction Standard

NFPA 90A & 90B

International Mechanical Code (IMC)

International Residential Code (IRC)

International Energy Conservation Code (IECC)

Uniform Mechanical Code (UMC)

## 2012 International Mechanical Code (IMC) requirements for flexible air ducts and air connectors -

**603.6 Flexible air ducts and flexible air connectors.** Flexible air ducts, both metallic and nonmetallic, shall comply with Sections 603.6.1, 603.6.1.1, 603.6.3 and 603.6.4. Flexible air connectors, both metallic and nonmetallic, shall comply with Sections 603.6.2 through 603.6.4.

**603.6.1 Flexible air ducts.** Flexible air ducts, both metallic and nonmetallic, shall be tested in accordance with UL 181. Such ducts shall be listed and labeled as Class 0 or Class 1 flexible air ducts and shall be installed in accordance with Section 304.1.

**603.6.1.1 Duct length.** Flexible air ducts shall not be limited in length.

**603.6.2 Flexible air connectors.** Flexible air connectors, both metallic and nonmetallic, shall be tested in accordance with UL 181. Such connectors shall be listed and labeled as Class 0 or Class 1 flexible air connectors and shall be installed in accordance with Section 304.1.

**603.6.2.1 Connector length.** Flexible air connectors shall be limited in length to 14 feet (4267 mm).

**603.6.2.2 Connector penetration limitations.** Flexible air connectors shall not pass through any wall, floor or ceiling.

**603.6.3 Air temperature.** The design temperature of air to be conveyed in flexible air ducts and flexible air connectors shall be less than 250°F (121°C).

**603.6.4 Flexible air duct and air connector clearance.** Flexible air ducts and air connectors shall be installed with a minimum clearance to an appliance as specified in the appliance manufacturer's installation instructions.

## 2012 NFPA 90A requirements for flexible air ducts and air connectors -

### 4.3.1 Air Ducts.

**4.3.1.2** Class 0 or Class 1 rigid or flexible air ducts tested in accordance with ANSI/UL181, *Standard for Safety Factory-Made Air Ducts and Air Connectors*, and installed in conformance with the conditions of listing shall be permitted to be used for ducts where temperature in the ducts does not exceed 121C (250F) or where used as vertical ducts serving not more than two adjacent stories in height.

### 4.3.2 Air Connectors.

**4.3.2.1** Air Connectors are limited-use, flexible air ducts that shall not be required to conform to the provisions for air ducts where they meet the requirements of 4.3.2.1.1 through 4.3.2.1.5.

**4.3.2.1.1** Air connectors shall conform to the requirements for Class 0 or Class 1 connectors when tested in accordance with ANSI/UL181, *Standard for Safety Factory-Made Air Ducts and Air Connectors*.

**4.3.2.1.2** Class 0 or Class 1 air connectors shall not be used for ducts containing air at temperatures in excess of 121C (250F).

**4.3.2.1.3** Air connector runs shall not exceed 4.27 m (14 ft.).

**4.3.2.1.4** Air connectors shall not pass through any wall, partition, or enclosure of a vertical shaft that is required to have a fire resistance rating of 1 hour or more.

**4.3.2.1.5** Air connectors shall not pass through floors.