



The Foibles, Follies, and Fixes of Flex

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Energy Vanguard

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M&M Manufacturing

THE
JOY OF SEX

ALEX COMFORT, M.B., Ph.D.

A Gourmet Guide



**NEWLY REVISED
AND UPDATED**

The Joy of Flex





















MATCHMA
MAX
PFF SCENT

PFF SCENT
MAX
PFF SCENT







A FLEX

AFLEX Class 1 Air Duct

7" II

- Codes and Approvals:
- MEETS NFPA 94 and 98
 - COMPLIES WITH UMC 10-1
 - THERMAL CONDUCTANCE 0.23 MAX
 - MEETS MIN. PROPERTY ST. 575A HUD





... 100 LBS FOR YOU PLEASE ...

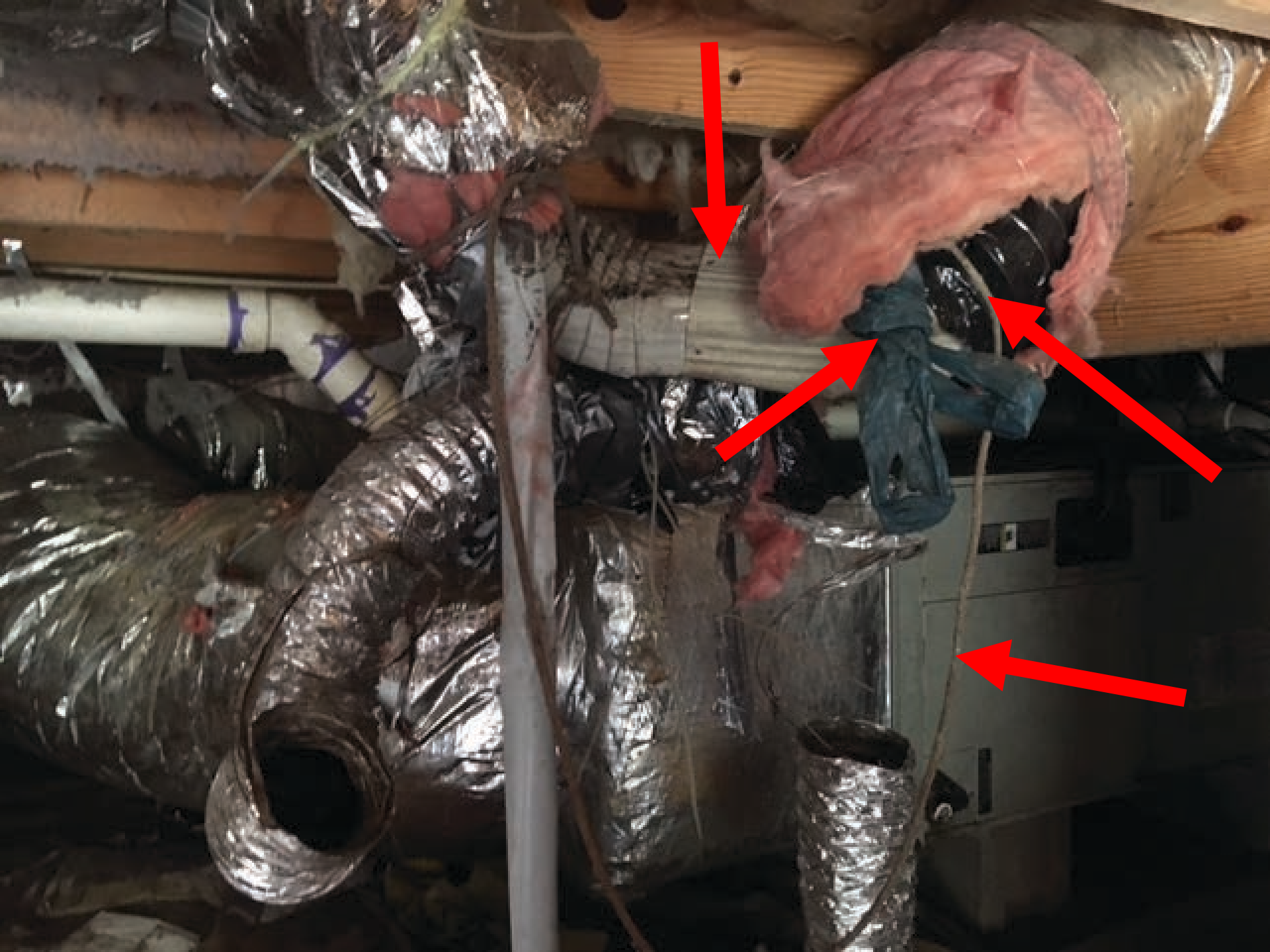


Fig. 1.





DUNDAS JAFINE

Air

1 cubic foot weighs 1/10 lb.
(almost)



Image courtesy of David Hill, Eneready Products,
used with permission



EFG

MOUNTAIN
HARD
WEAR
CLIMB TEAM

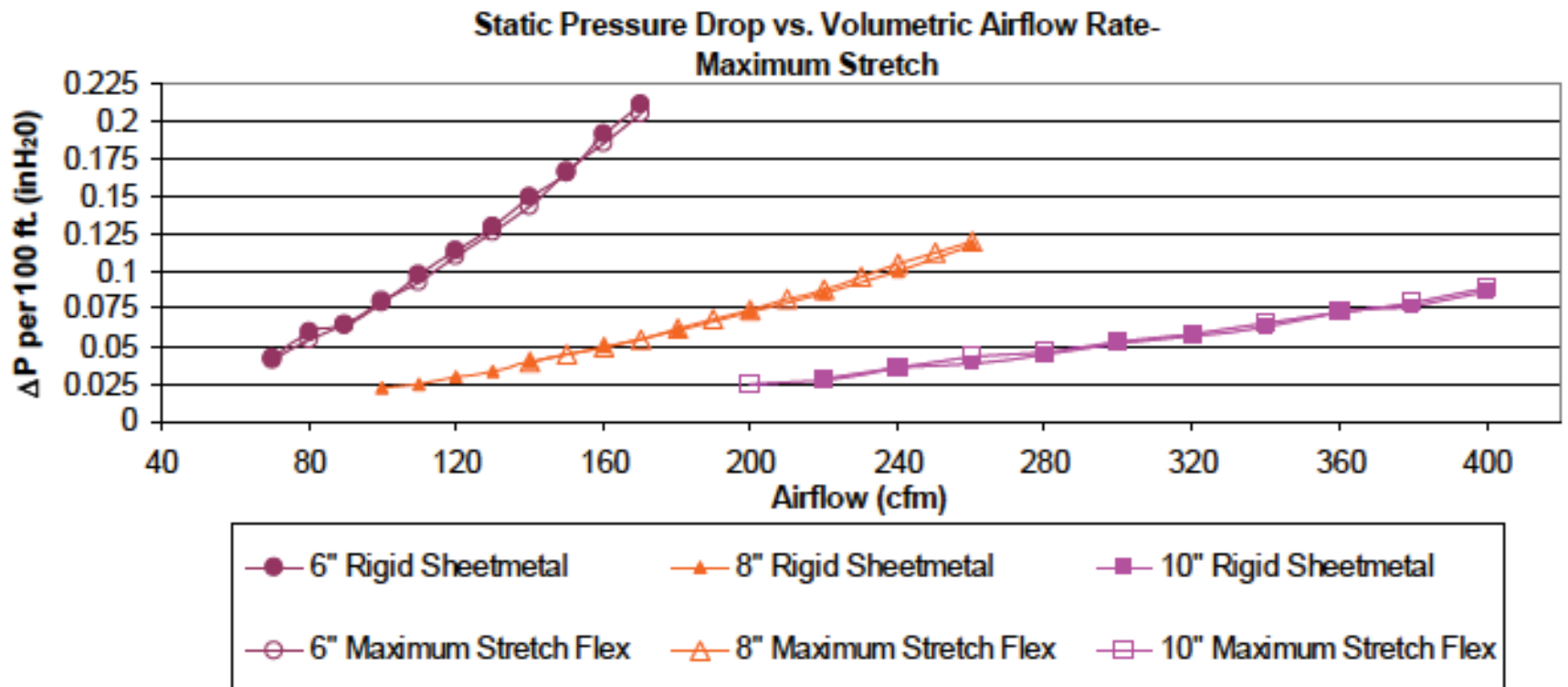
$$t = \sqrt{\frac{2h}{g}}$$

The 2 Causes of Reduced Air Flow

1. Friction



Rigid vs. Flex



2. Turbulence

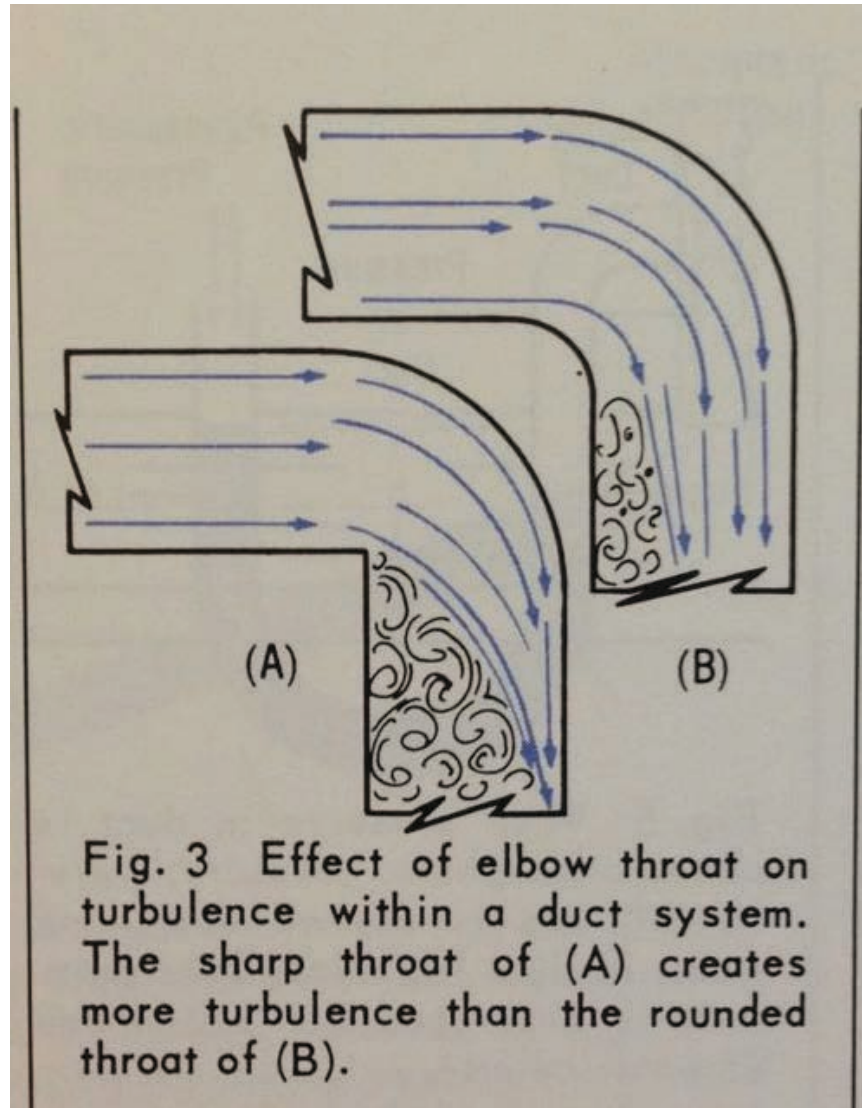
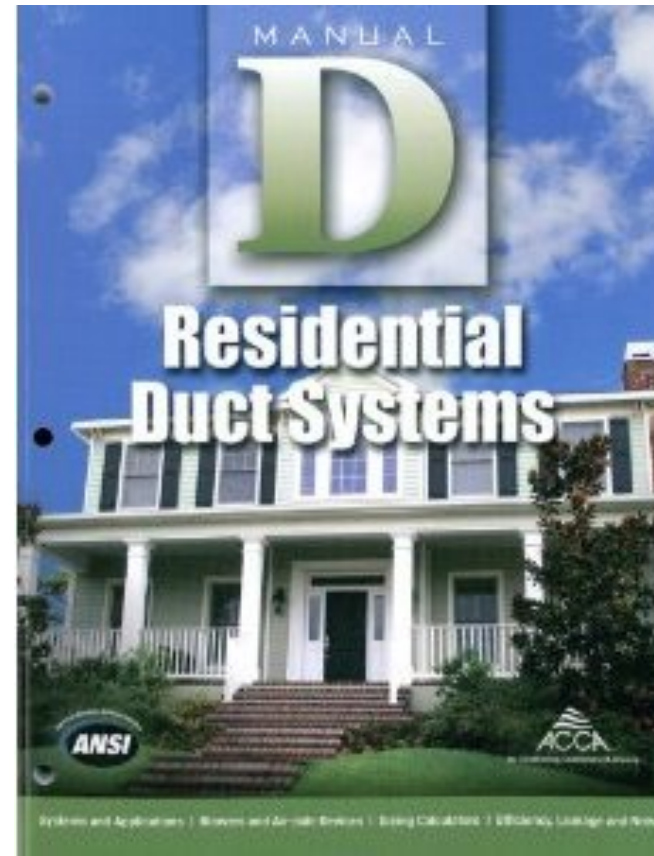
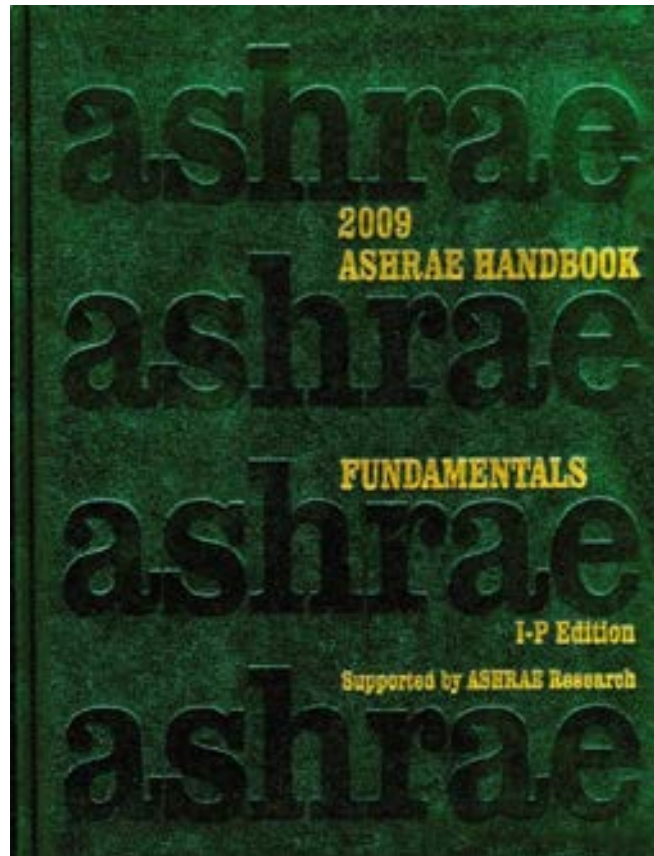


Image from
Understanding the Friction Chart, by the Air Conditioning Contractors of America



The Duct Design Process

Duct Design Reference Books

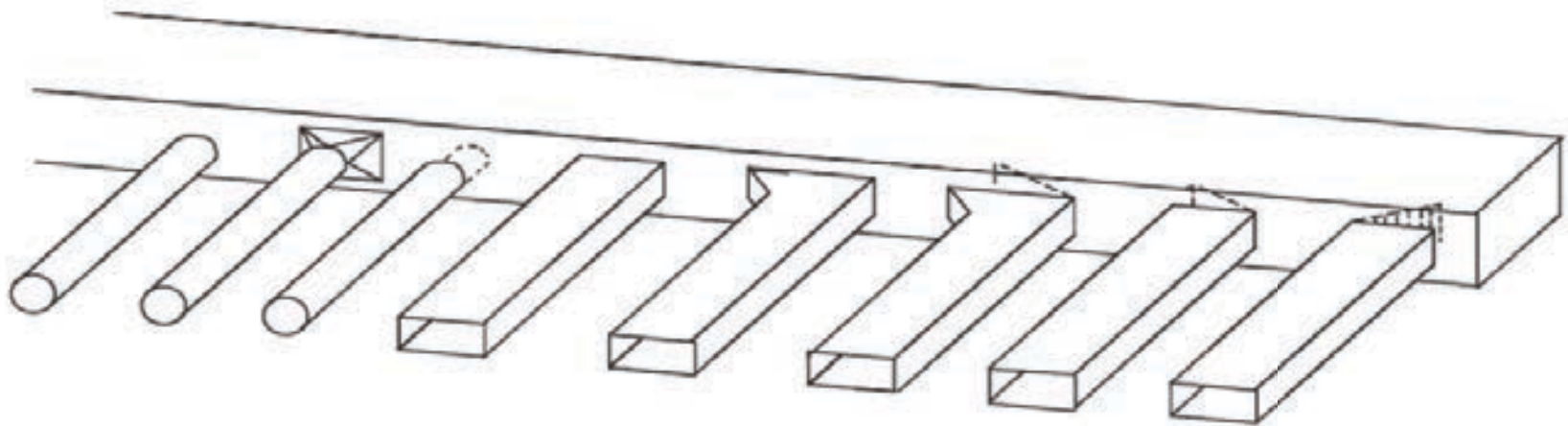










Available Static Pressure

Equivalent Length

Friction Rate





EL Values		Number of Downstream Branches to End of Trunk Duct or Number of Downstream Branches to a Trunk Reducer					
Fitting		0	1	2	3	4	5 or More
	2A	35	45	55	65	70	80
	2B	20	30	35	40	45	50
	2C	65	65	65	65	70	80
	2D	40	50	60	65	75	85
	2E	25	30	35	40	45	50
	2F	20	20	20	20	25	25
	2G	65	65	65	70	80	90
	2H	70	70	70	75	85	95

Note: If the trunk has a reducer, count down to the reducer; then begin a new count after the reducer.

Image from Manual D, used with permission
from Air Conditioning Contractors of America



Image from Manual D,
 used with permission
 from Air Conditioning
 Contractors of
 America



Round and Oval Elbow EL Values









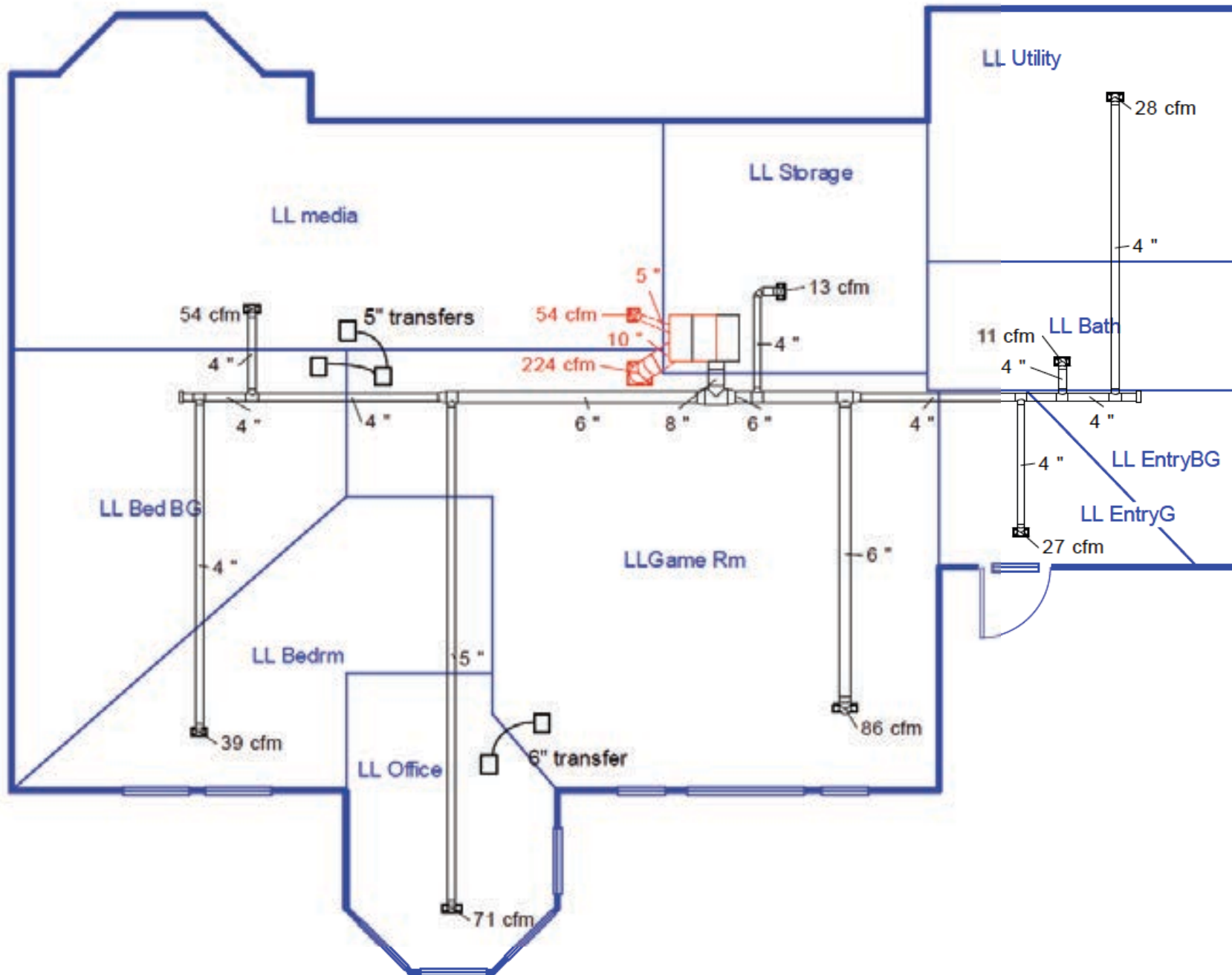
								
R/D	Smooth	4 or 5 Piece	3 Piece	Smooth Mitered	Easy Bend	Hard Bend	3-Piece 45°	2-Piece 45°
Mitered (R = 0)	—	—	—	75	4-Piece 25	4-Piece 30	10	15
0.75	20	30	35	—				
1.0	15	20	25	—	3-Piece 30	3-Piece 35		
1.5 or Larger	10	15	20	—				

Image from Manual D, used with permission from Air Conditioning Contractors of America





Supply Equivalent Length of Fittings

Manual D-Fittings

Fitting ID	Angle	Eq. length (ft)
...		
4AD	90	60
8A8	90	35
2P3	90	65
9I1	90	85
1A	90	35
	90	0
	90	0
	90	0
	90	0
	90	0
	90	0
	90	0
	90	0

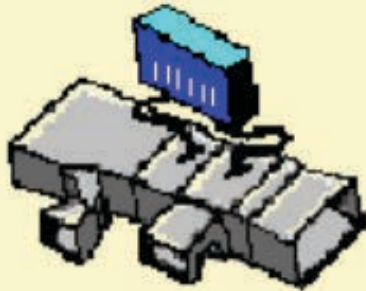
User Defined Fittings

Fitting ID	Eq. length (ft)
USR1	0
USR2	0
USR3	0

Total Equivalent Length

280 ft

Close



Measured length of run-out

Measured length of trunk

Equivalent length of fittings

Total length

Total effective length

Supply
(ft)

Return
(ft)

2

13

34

0

290

...

85

...

326

98

Rectangular Snip

424

Fittings dominate pressure drops...

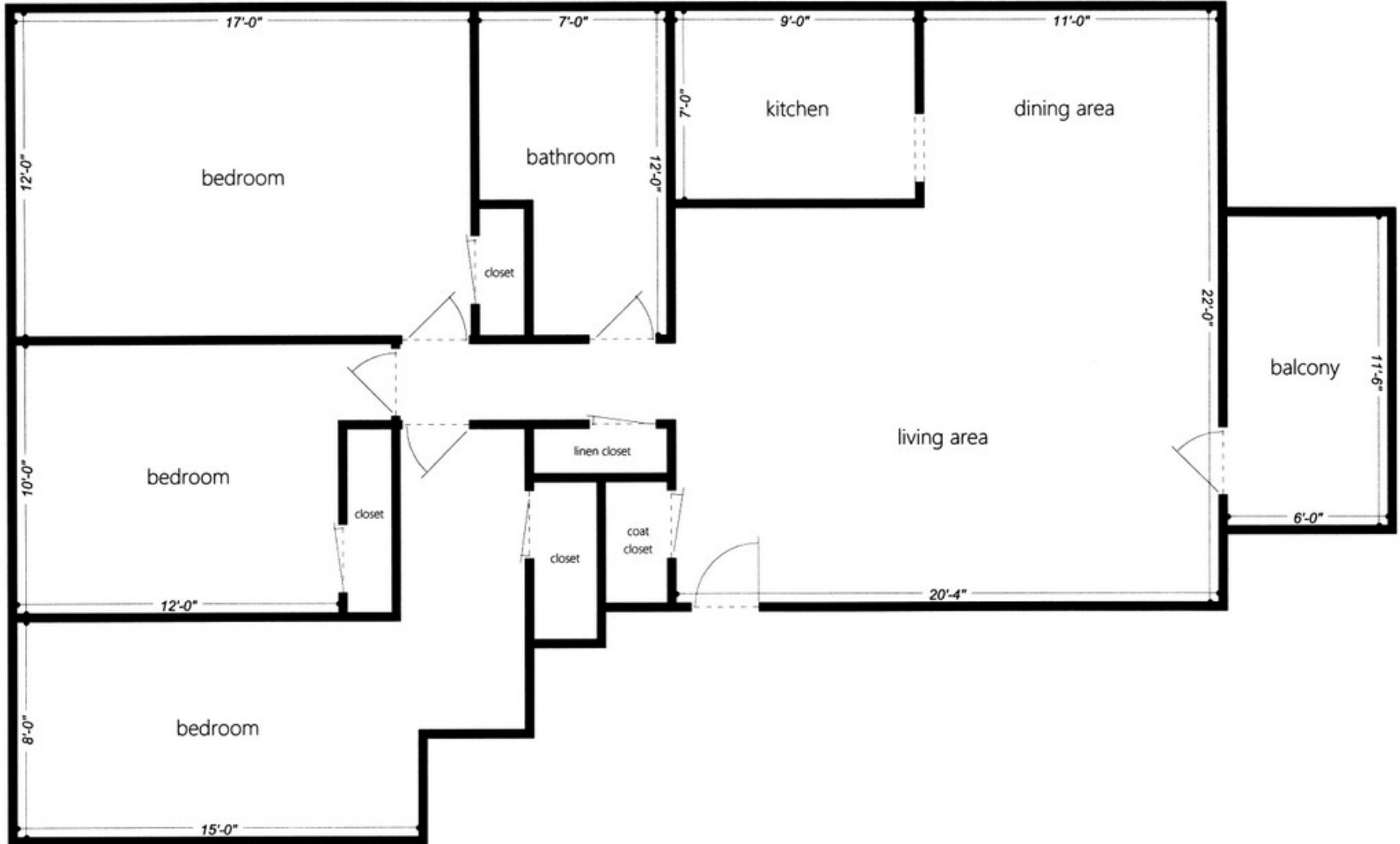




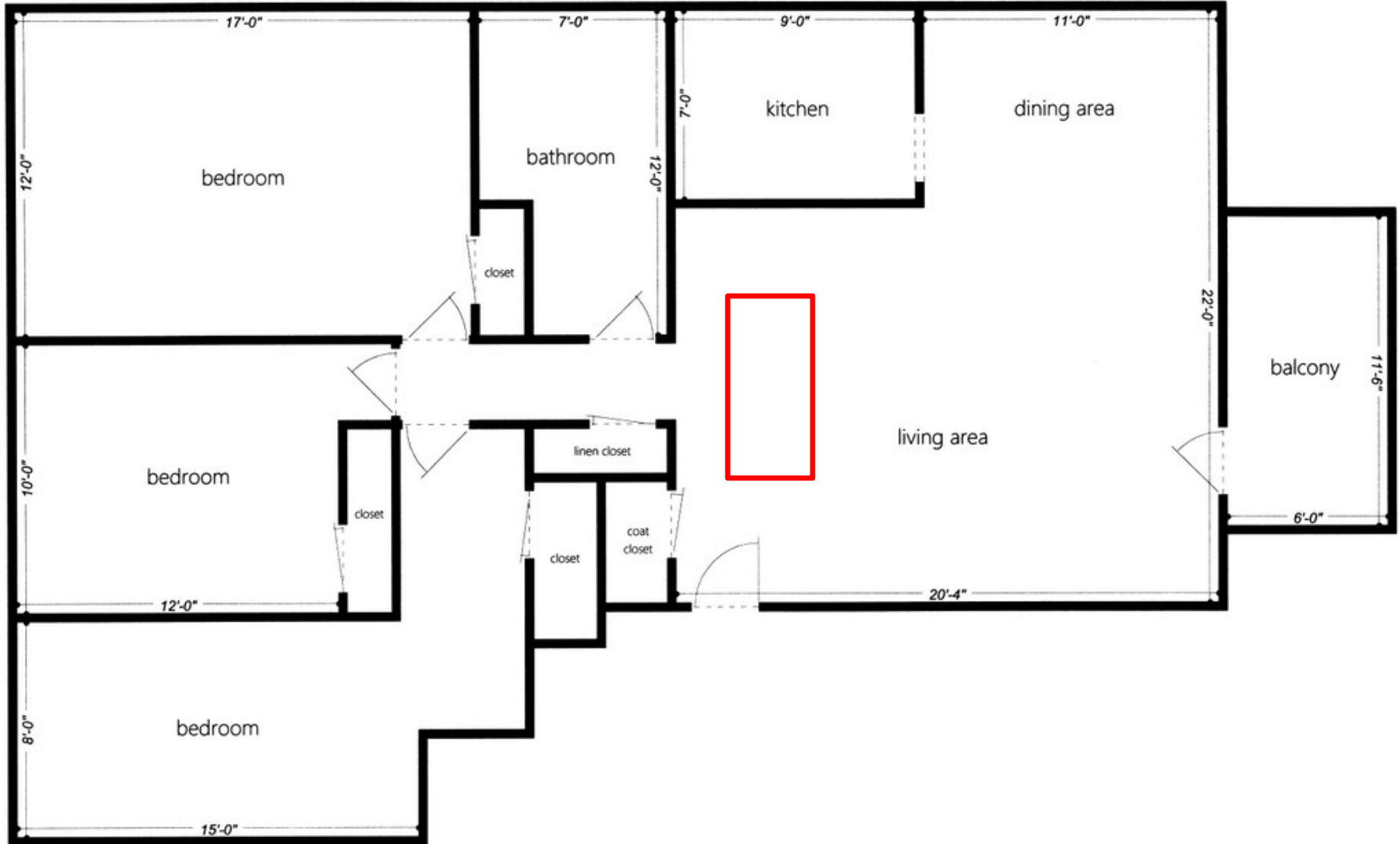
Poorly installed flex duct can be just as
bad for air flow

From Fantasy to Reality

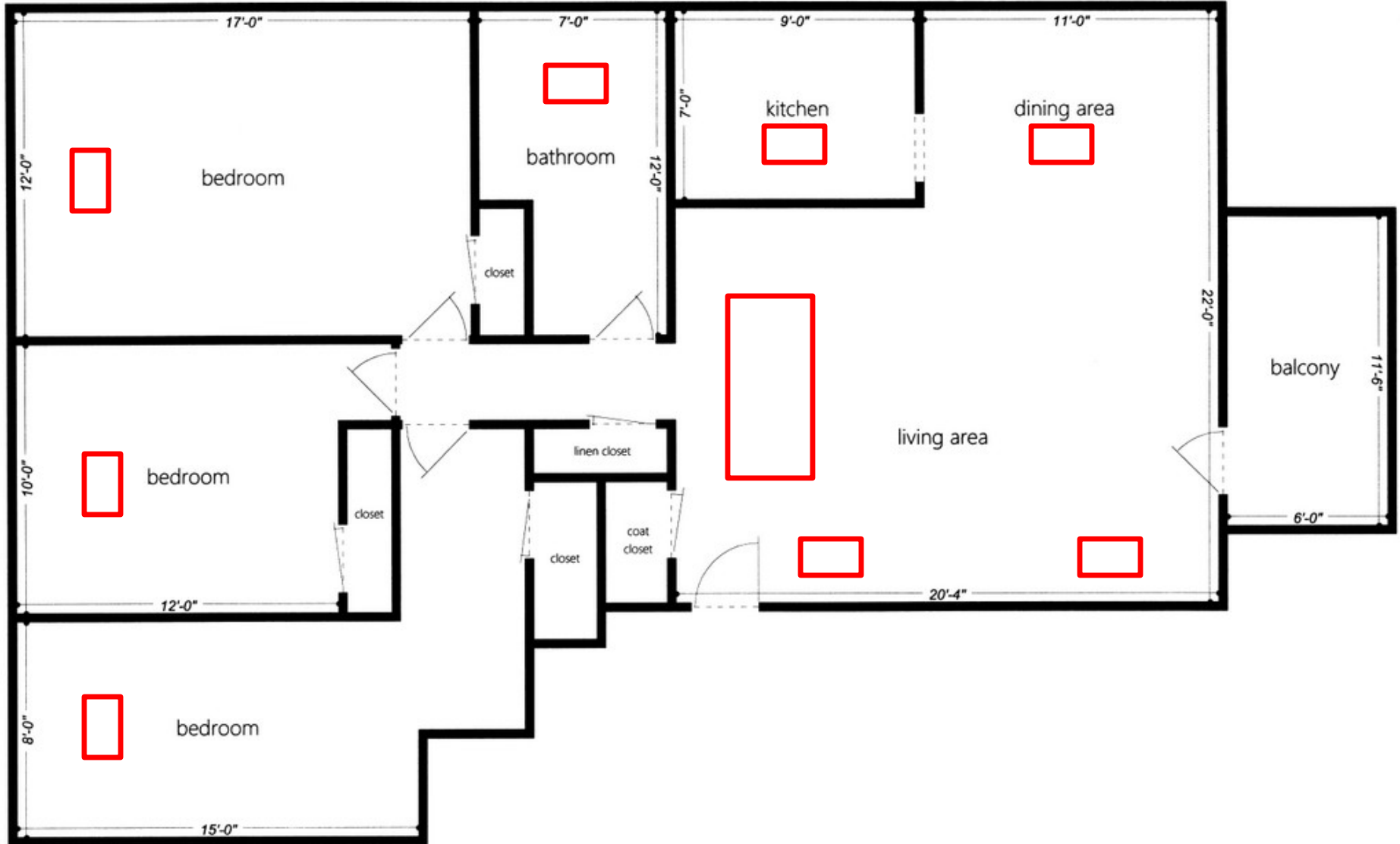
Duct Layout



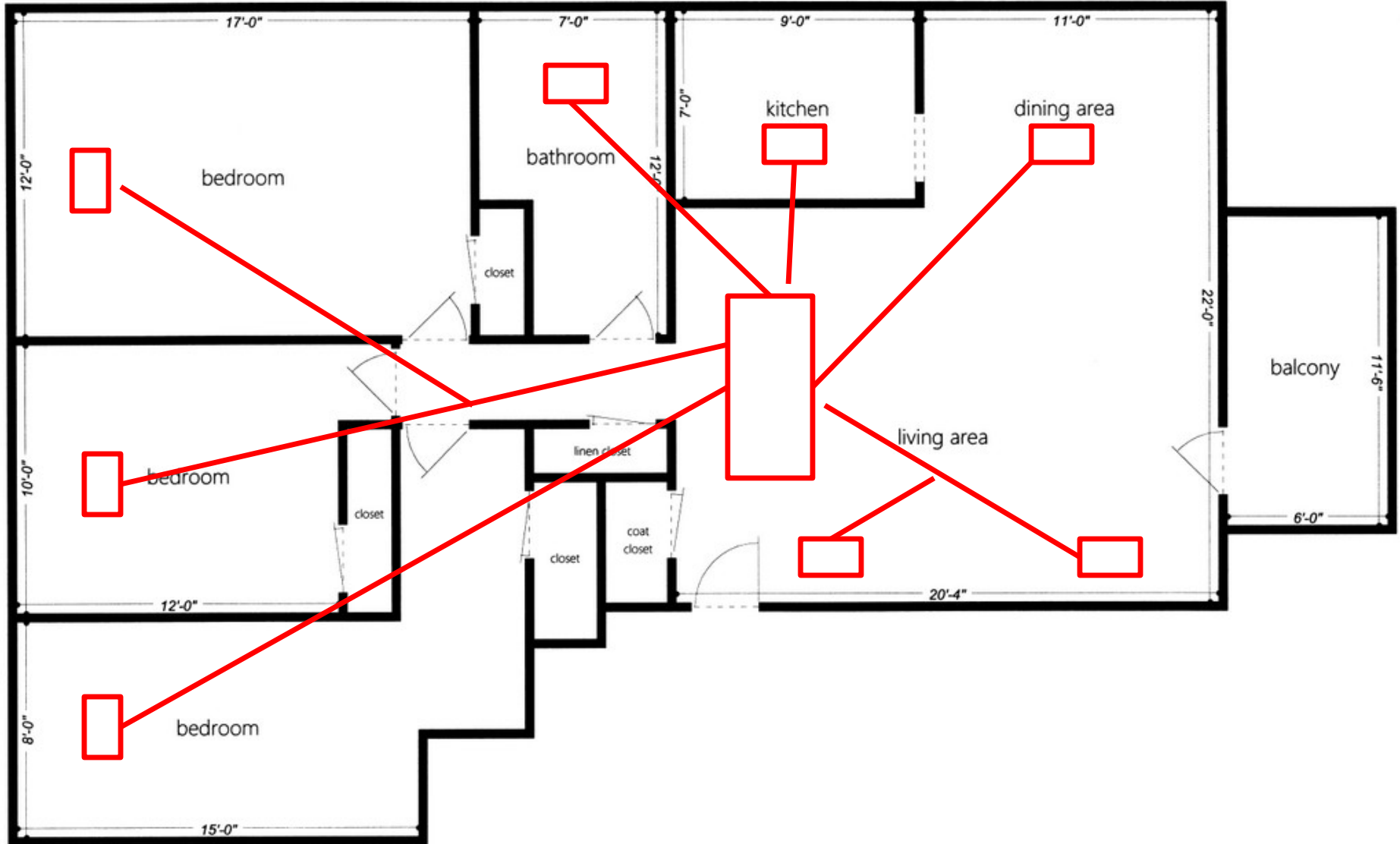
Duct Layout



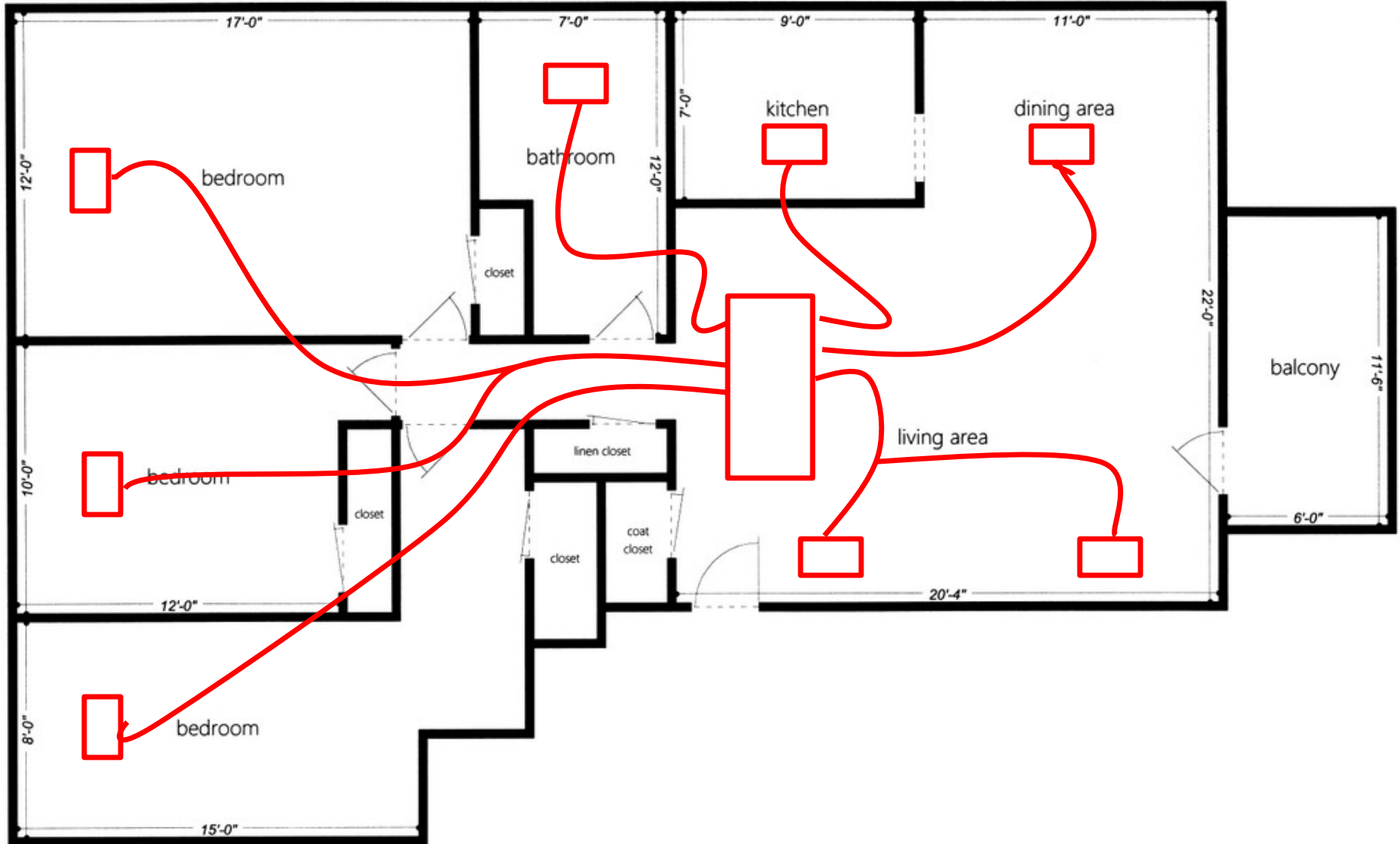
Duct Layout



Duct Layout



Duct Layout



AIR DIFFUSION COUNCIL
Manufacturers of Flexible Air Duct

Flexible Duct Performance & Installation Standards

Fifth Edition

AIRC - AIR DIFFUSION COUNCIL

AIR DIFFUSION COUNCIL

AIRC - AIR DIFFUSION COUNCIL, SCHMUNGBURG, ILLINOIS



Air Duct Council

Flexible Duct Performance & Installation Standards Installation Guidelines

“Install duct fully extended, do not install in the compressed state or use excess lengths. This will noticeably increase friction losses”.

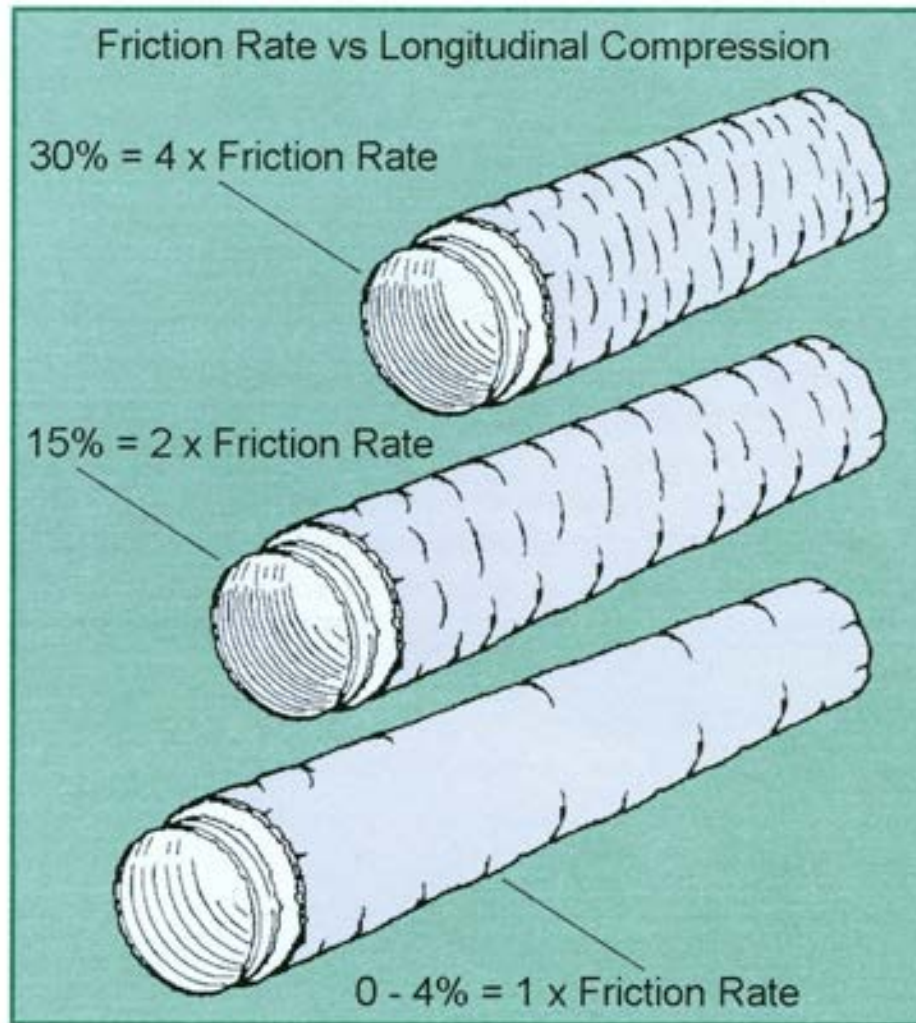


Figure 10 - Compressed duct (not fully extended) increases friction rate.

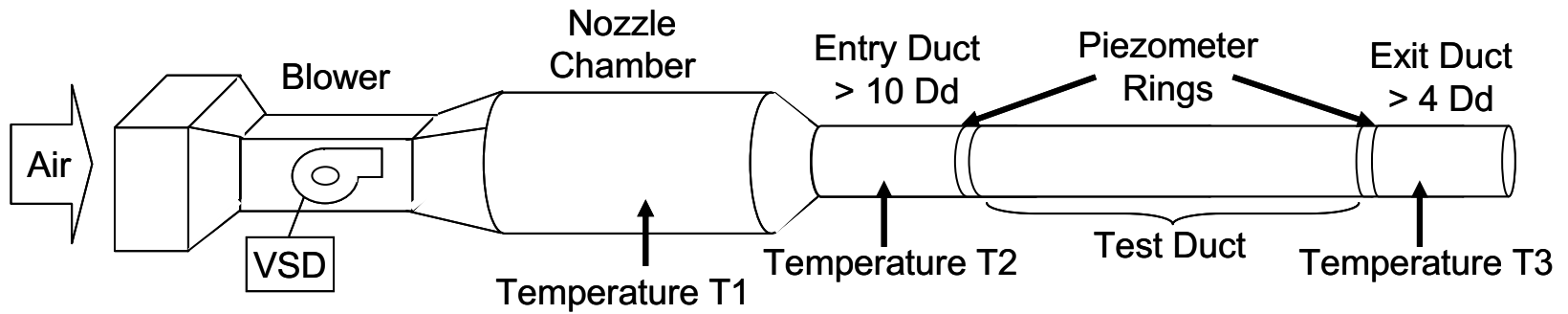
Pressure Drop Research

**Static Pressure Losses in
6", 8", and 10" Non-Metallic Flexible Duct**

Kevin Weaver, EIT, Graduate Research Assistant*
Charles Culp, Ph.D., P.E., ASHRAE Fellow, Associate Professor

Texas A&M University

Data Acquisition (DAQ) setup



- ANSI / ASHRAE Standard 120 requirements were used to design the system and process the data after acquisition.

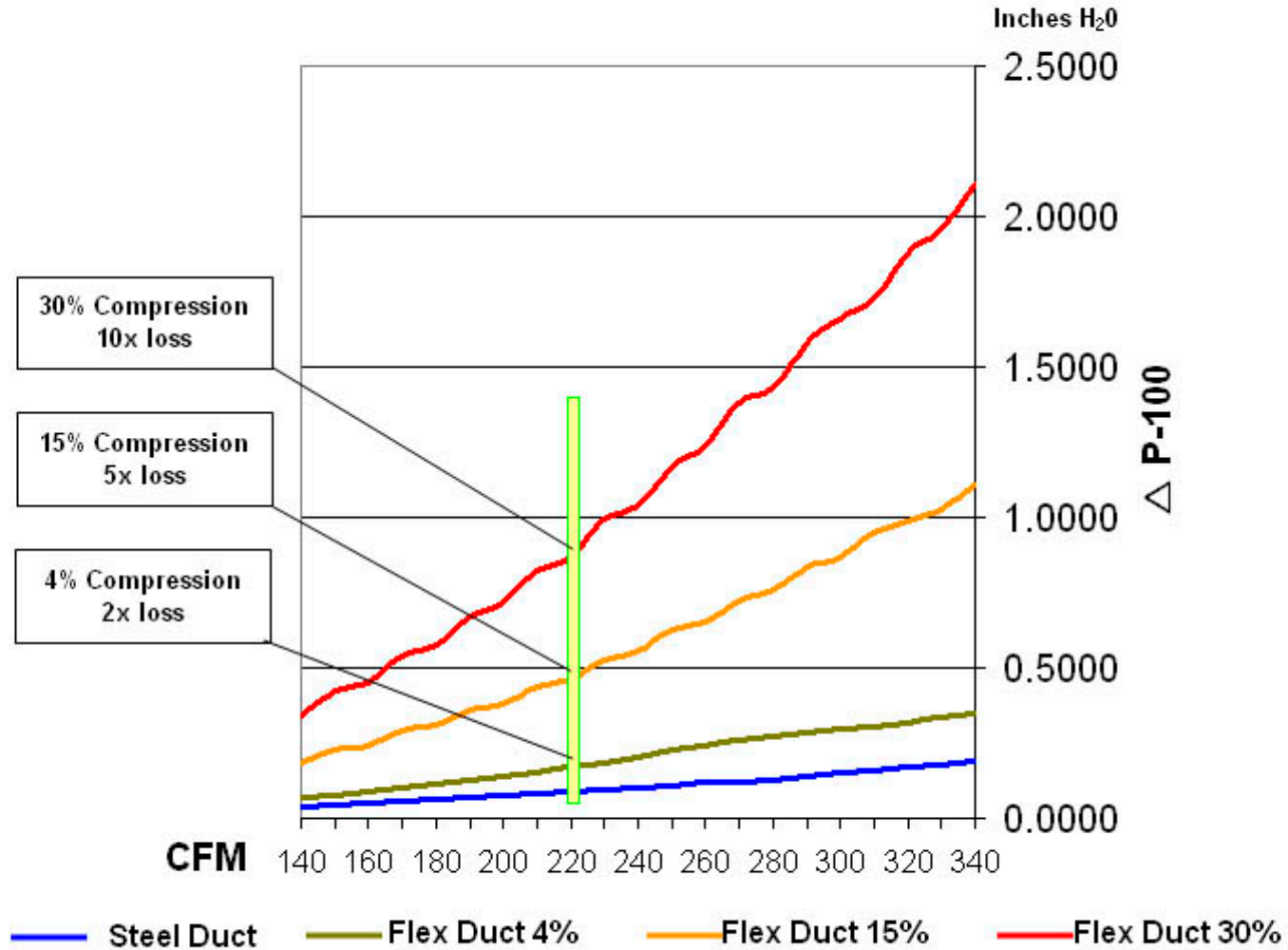
ANSI / ASHRAE Standard 120 Testing Protocol



ANSI / ASHRAE Standard 120 Testing Protocol

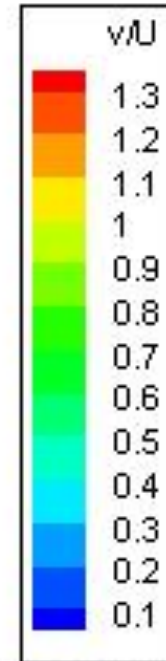
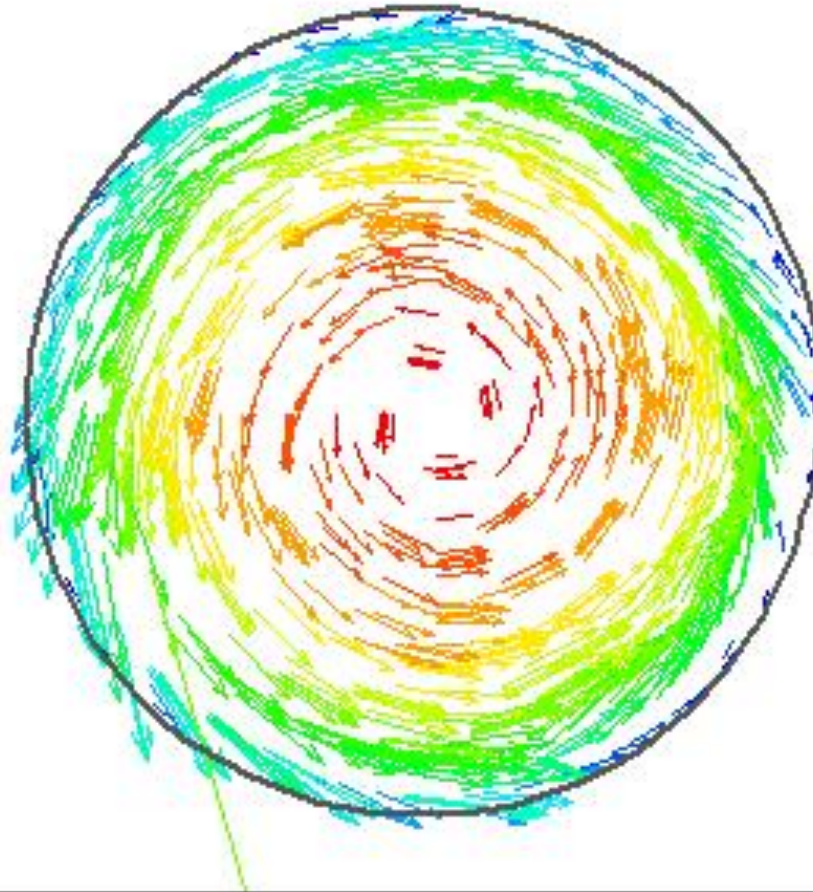


8" Straight Flex-Duct Compression vs. Steel Duct Per ASHRAE Std. 120



Computational Fluid Dynamics (CFD)

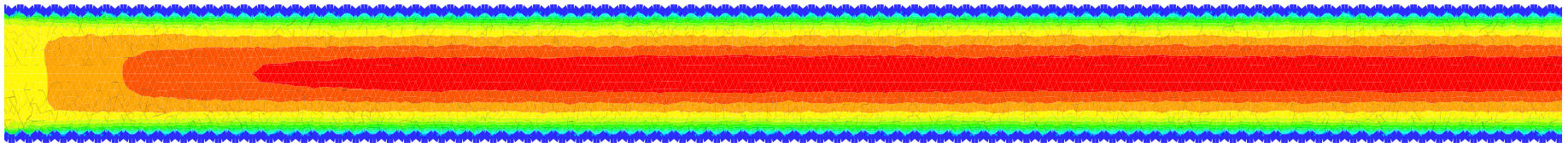
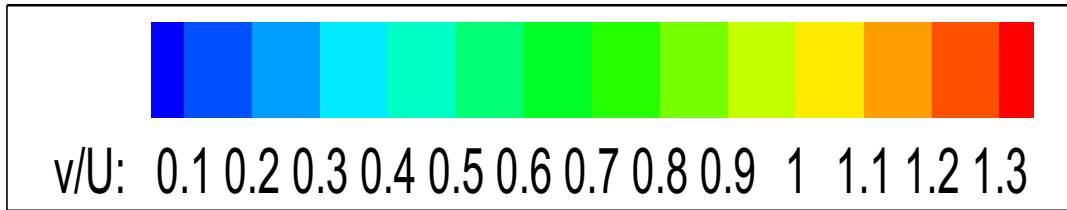
Computer Generated Model of Air Flow in Flex



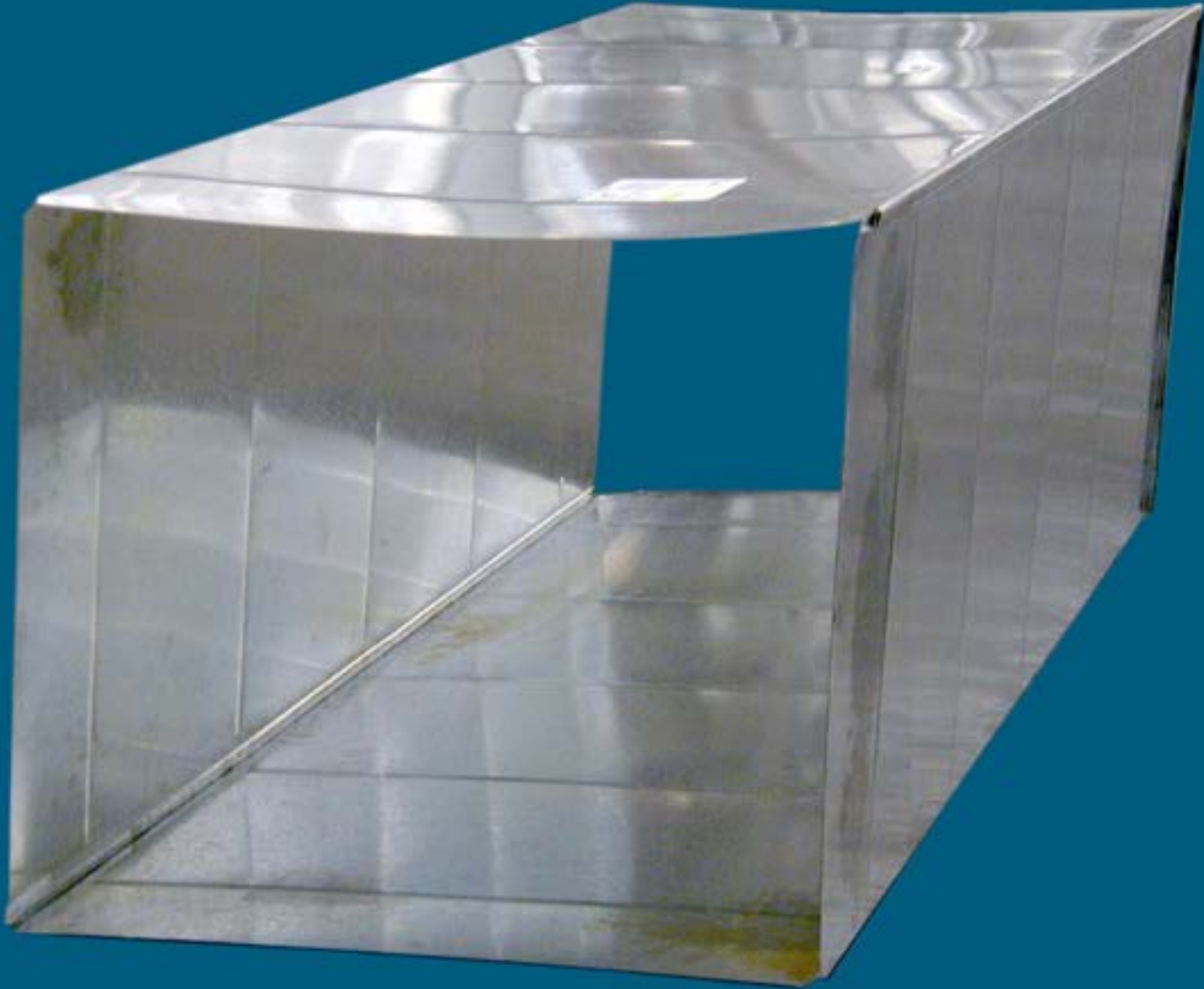
$x/L=0.825, L=4m$

Computational Fluid Dynamics (CFD)

Computer Generated Model of Air Flow in Flex



The New ASHRAE Duct Calculator









GREEN TAG





GREEN TAG



www.ashrae.org

This Duct Size Calculator is intended for use as a quick reference tool for approximating duct sizes and equivalent sizes of sheet metal duct versus flexible duct. For more information please refer to the ASHRAE Handbook – Fundamentals chapter, Duct Design.



www.steelduct.org

**I-P (Inch-Pound)
DUCT SIZE
CALCULATOR**



Quick Reference Tool

The equations below were used to calculate the values given in this duct size calculator.

A friction loss of 0.08 in. water per 100 ft. was used as a baseline reference.

The pressure loss per unit length through a round sheet metal duct or a wire-wound flexible duct was calculated using the Darcy equation:

$$\frac{\Delta p_f}{L} = \frac{12f}{D} \rho \left(\frac{V}{1097} \right)^2$$

For either type of duct, the friction factor was determined using the Colebrook equation:

$$\frac{1}{\sqrt{f}} = -2 \log \left[\frac{12\epsilon/D}{3.7} + \frac{2.51}{\text{Re}\sqrt{f}} \right]$$

To account for the increase in pressure loss that occurs when a flexible duct has a percent duct compression K_c , a pressure drop correction factor was used.

Therefore, the flexible duct diameter D_{fl} that yielded the same pressure loss per unit length as a sheet metal duct with a prescribed diameter D_{sm} at a specified average air velocity was evaluated iteratively using

$$\frac{f_{sm}}{D_{sm}} V_{sm}^2 - \frac{f_{fl}}{D_{fl}} V_{fl}^2 \left(1 + 0.58 K_c \cdot e^{-0.126 D_{fl}} \right) = 0$$

Calculator based on duct roughness factor $\epsilon = 0.0003$ and 0.003 ft for sheet metal and flex duct: standard air ($\rho = 0.075 \text{ lb}_m/\text{ft}^3$).

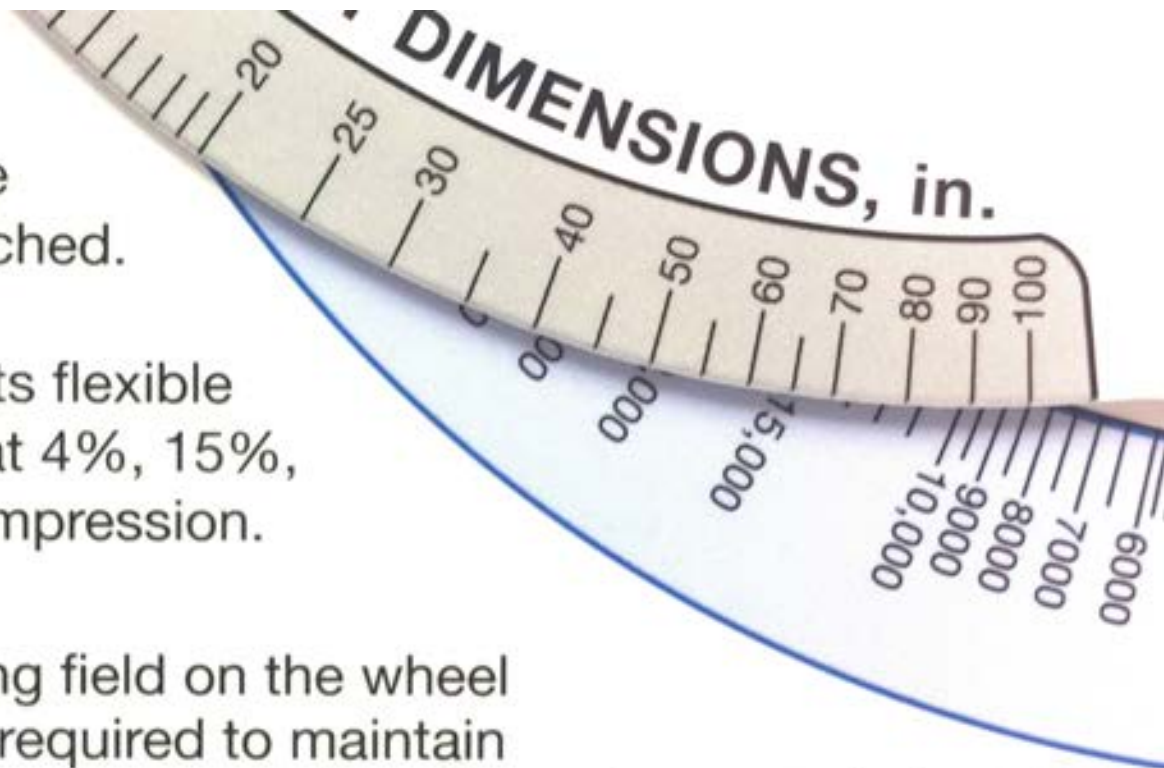
Laboratory Data compared within 10% of calculated values, so ASHRAE published formulas were used to create this tool.

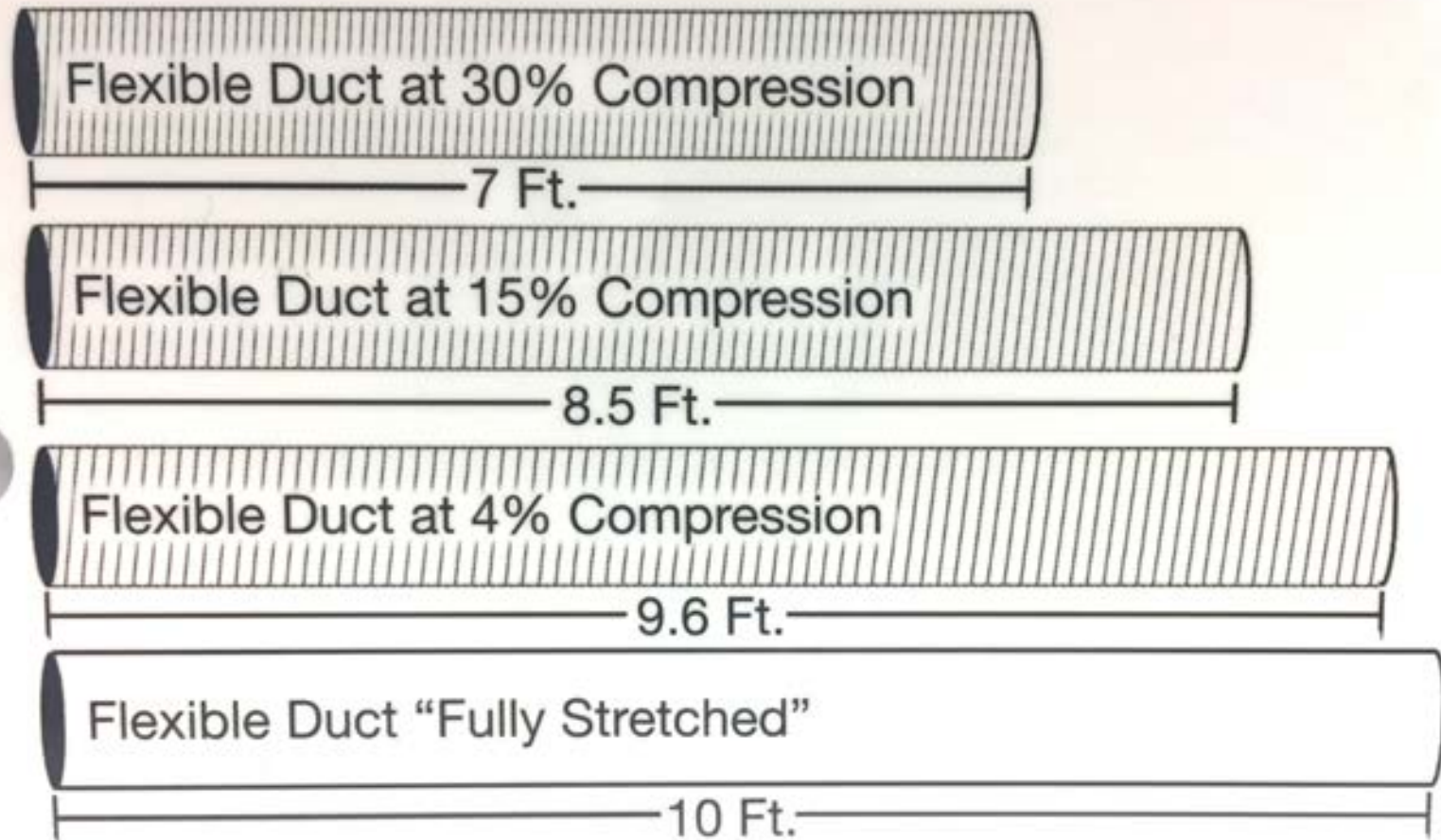
Friction loss increases significantly when flexible duct is not properly stretched.

The graphic below depicts flexible duct when compressed at 4%, 15%, and 30% straight line compression.

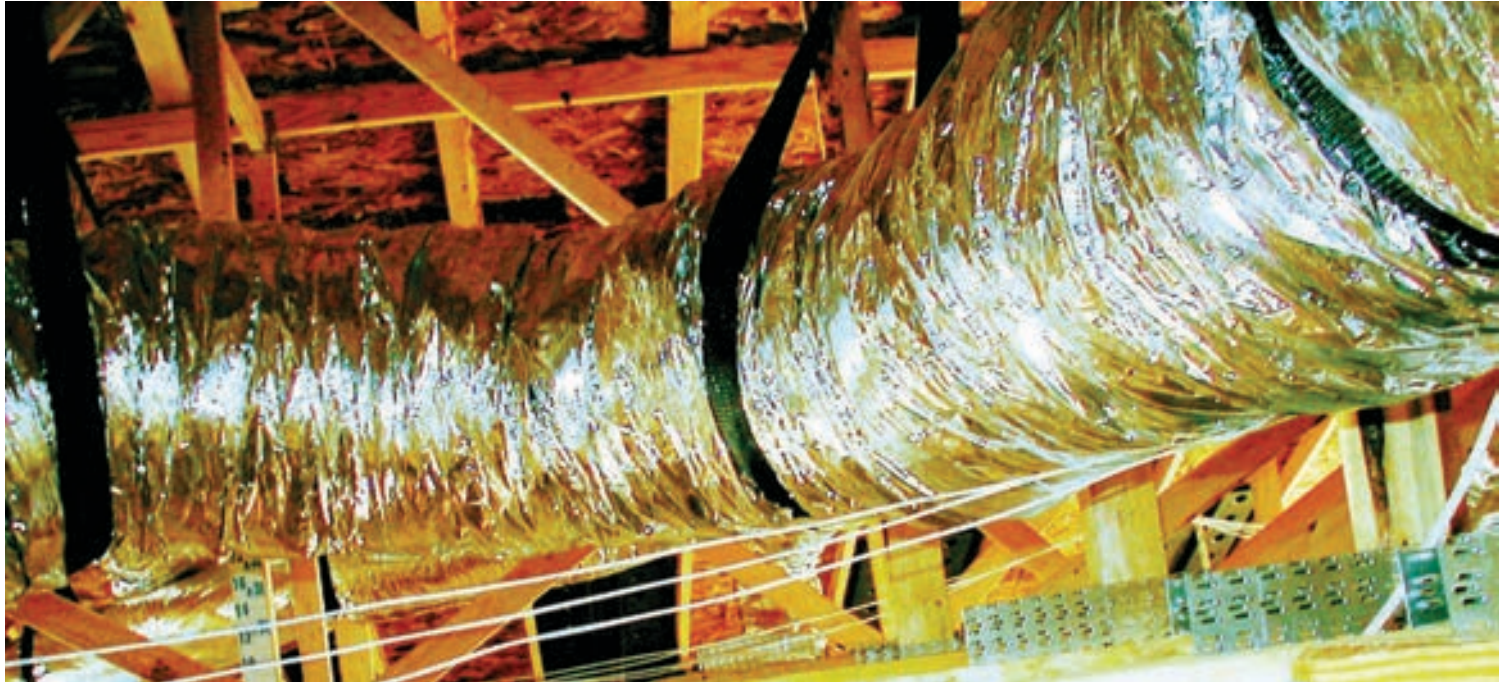
Refer to the corresponding field on the wheel to read flexible duct size required to maintain equivalent airflow and same pressure loss for a given metal duct size.

Note: *Bends, curves, and excessive lengths in flexible duct will increase friction losses.*

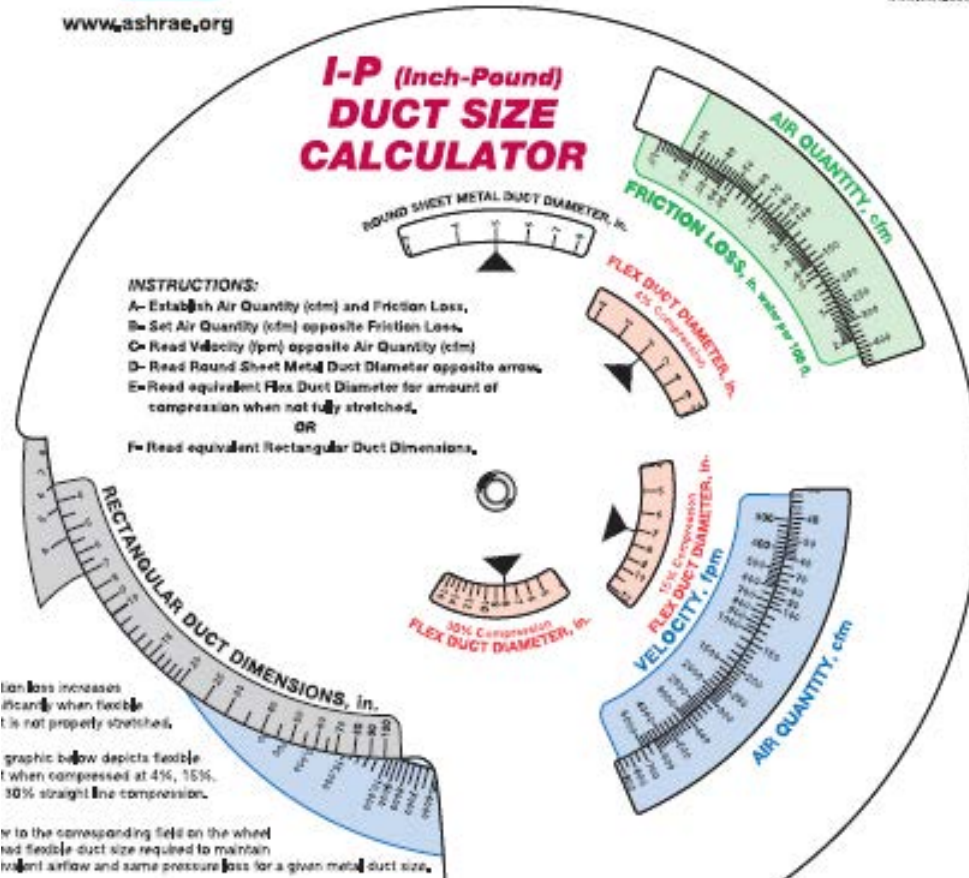




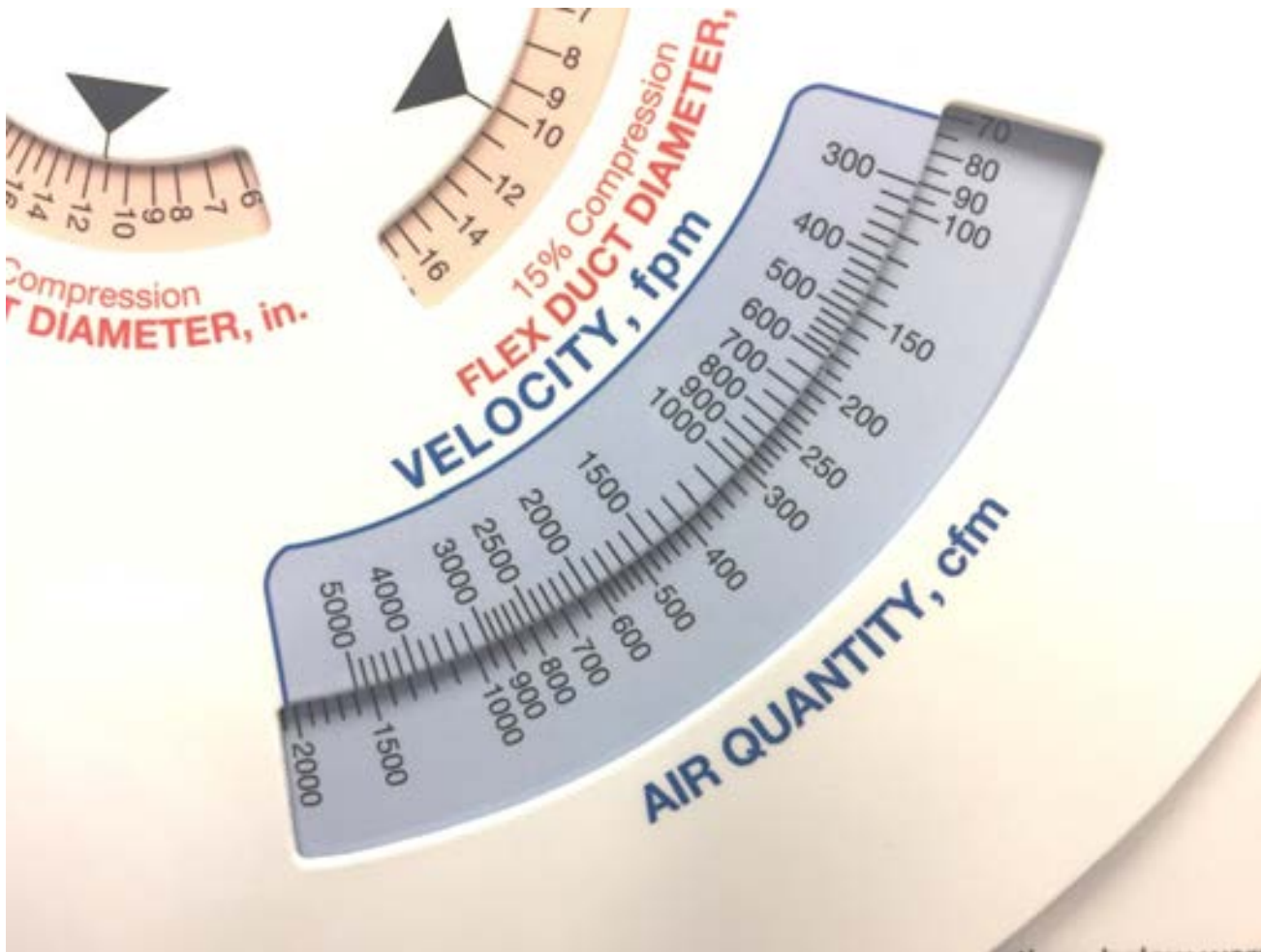
Compression Graphic



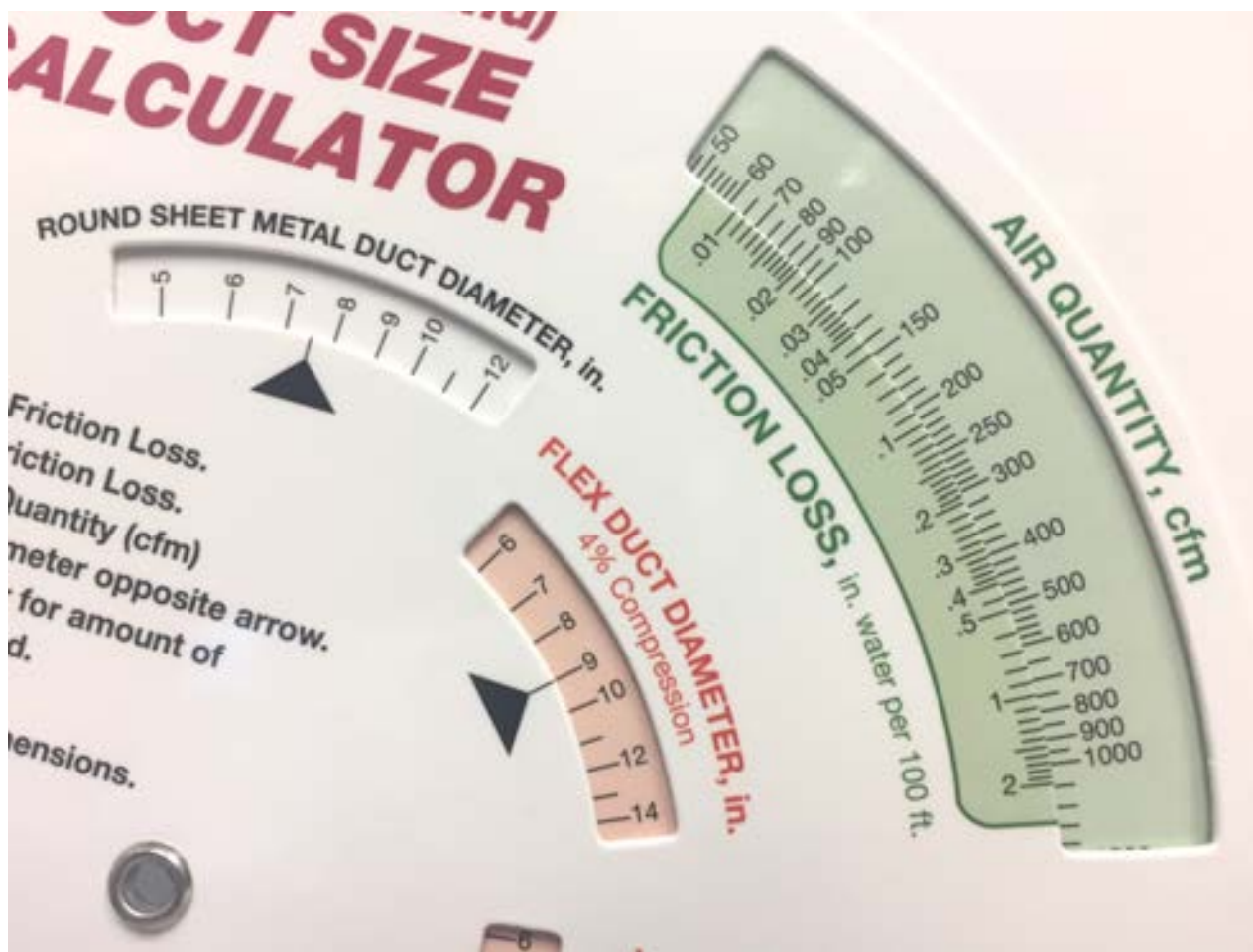
30% Compression in Flexible Duct



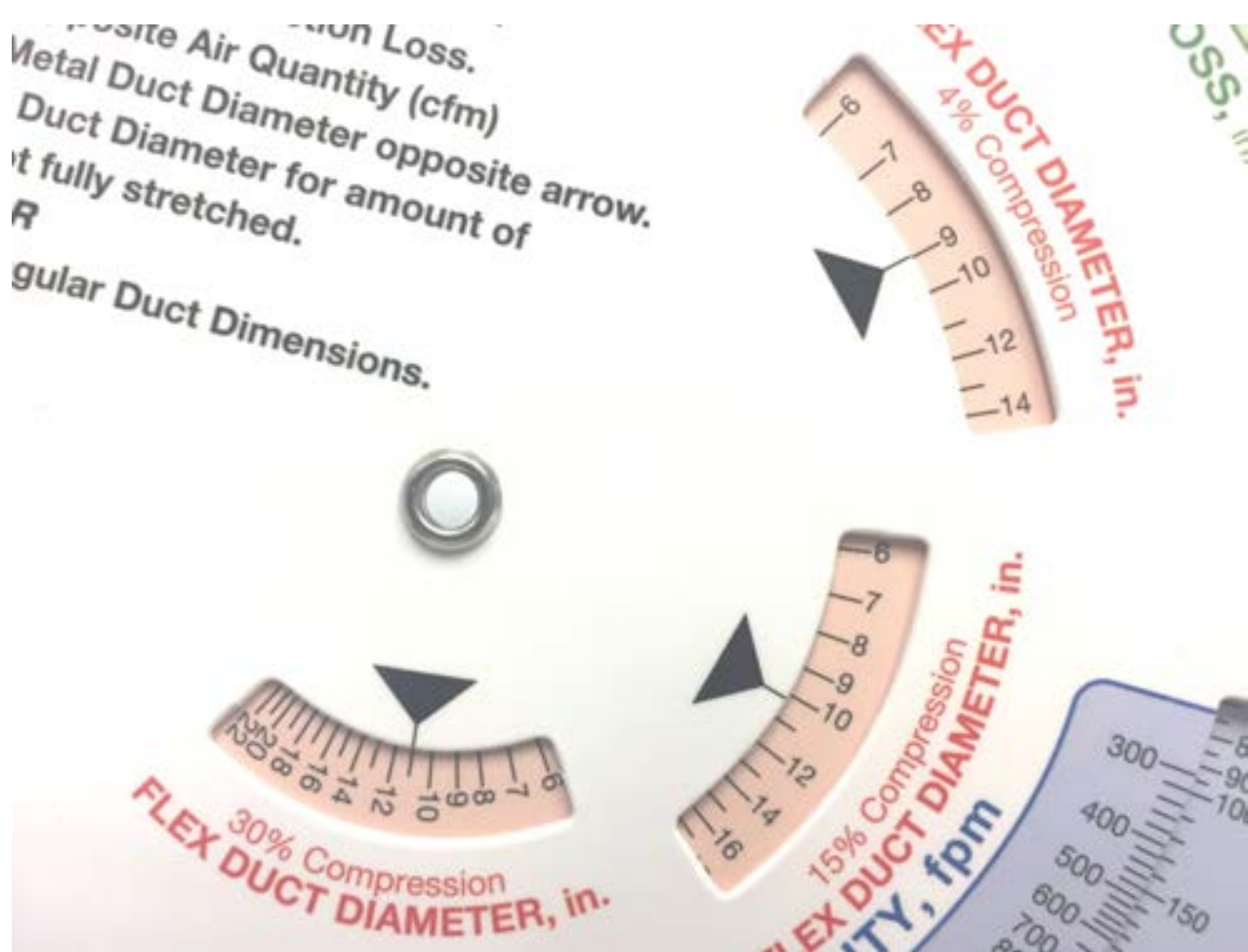
Round Sheet Metal Duct vs Flexible Duct 4%, 15%, 30% Compression



200 cfm / 650 fpm



**8" Round Sheet Metal Duct =
9" Flexible Duct at 4% compression
.08"-.09" Friction Loss**



**8" Round Metal Duct =
10" Flexible Duct at 15% Compression,
12" Flexible Duct at 30% Compression**

Is Rigid Duct the Answer?

Uniform Mechanical Code

603.4.1 Length Limitation. Factory-made flexible air ducts and connectors shall be not more than 5 feet (1524 mm) in length and shall not be used in lieu of rigid elbows or fittings. Flexible air ducts shall be permitted to be used as an elbow at a terminal device.

Exception: Residential occupancies.









Flex Duct Systems That Work

Gavin Healy



Dan Perunko



Mike MacFarland











Advantages of Flex Duct

- Options
- Cost
- Noise control
- Energy efficiency

But it has to installed properly!





Always Carry Flex Duct!

Questions?

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