DUCT AND DELIVERY SYSTEM

This is the **single most important component** of any heating & cooling system. It is therefore vitally important anyone considering the installation of a high efficiency geothermal heating and cooling system take time out to learn and understand a few basics regarding the duct work that goes into your home. The following is a short explanation to illustrate how every improper turn and bend in the duct work results in high heating and cooling bills, rooms with uneven temperatures, and in many cases, areas of total discomfort.

To realize the importance of a good duct system, a clear understanding of duct ***equivalent length*** relationship is necessary.

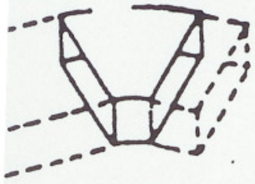
If you take an 8 inch round pipe, 2 feet long and bend it 90 degrees, the air flow decreases as it makes the turn because of the pressure build up. This pressure is now greater than it would be in that same 2 foot piece of pipe when it was straight. This pressure is measured and compared to a straight piece of pipe without any bends. The result is - the 8 inch round pipe - **2 feet long**, with a 90 degree bend, has the ***EQUIVALENT*** pressure of an 8 inch round straight piece of pipe **25 feet long**. This sample is from the ACCA (Air Conditioning Contractors Association) duct work engineering manual. So, if you live in a house that has hot and cold rooms, noisy air ducts, and high heating bills, the culprit is more than likely your delivery system.

For further reference and clarification, consult:
Air Conditioning Contractors of America
(ACCA) Manual D. 2nd edition
1513 16th St. NW. Washington, DC 20036

NOTE) C- Elbow has 5 times less Efficiency than E

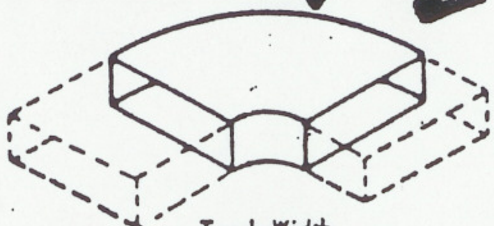
UP 5, ANGLES AND ELBOWS FOR TRUNK DUCTS
(Inside Radius = ½ Width of Duct)

yes NO yes



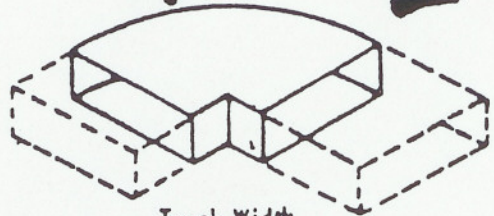
Trunk Width Inches

4 to 15 = 5 ft
16 to 27 = 10 ft
28 to 41 = 15 ft
42 to 52 = 20 ft
53 to 64 = 25 ft



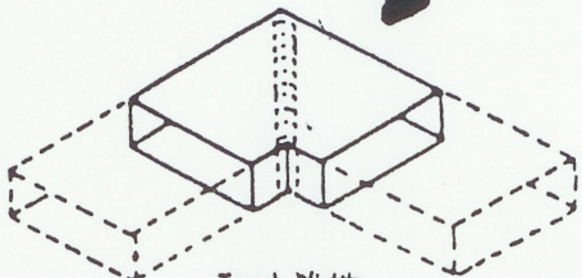
B - Trunk Width Inches

4 to 11 = 10 ft
12 to 21 = 15 ft
22 to 27 = 20 ft
28 to 33 = 25 ft
34 to 42 = 30 ft
43 to 51 = 40 ft
52 to 64 = 50 ft



C - Trunk Width Inches

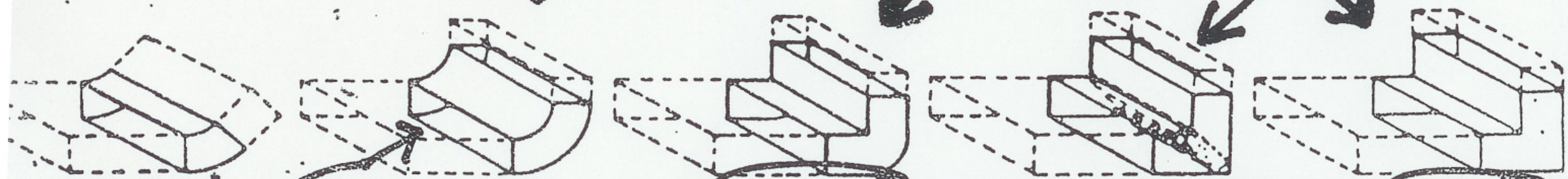
4 to 6 = 20 ft
7 to 11 = 40 ft
12 to 15 = 55 ft
16 to 21 = 75 ft
22 to 27 = 100 ft
28 to 33 = 125 ft
34 to 42 = 150 ft



D - Trunk Width Inches

4 to 11 = 15 ft
12 to 21 = 20 ft
22 to 27 = 25 ft
28 to 42 = 40 ft

yes — NO — yes



E = 5 ft F = 10 ft G = 30 ft H = 15 ft I = 30 ft

CHART A-7 Drawings of various iittings with equivlanet lengths shown

NOTE: NO GAIN with out side Radius.
INSIDE on turning VANES A must

Source

ACCA MANUAL D

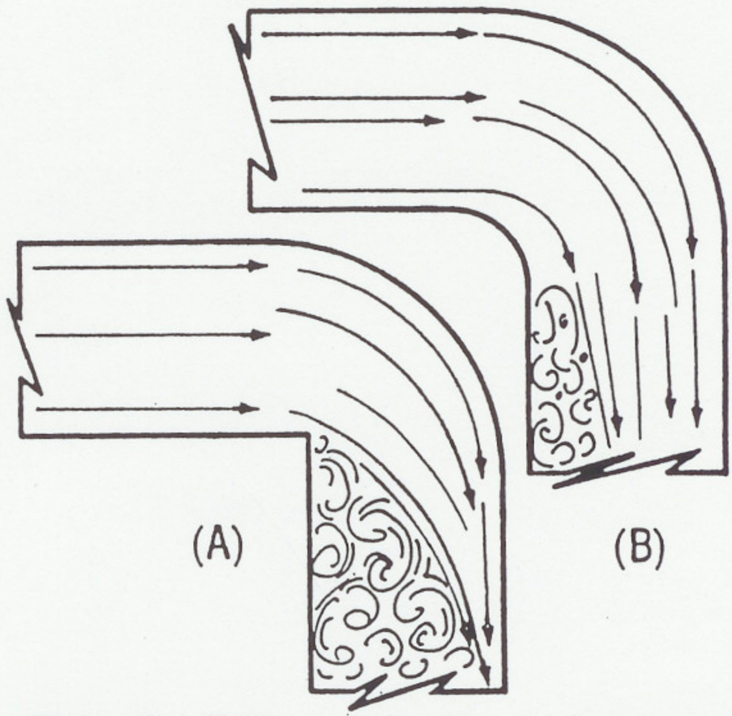


Fig. 3 Effect of elbow throat on turbulence within a duct system. The sharp throat of (A) creates more turbulence than the rounded throat of (B).

ELBOWING YOUR WAY THROUGH DUCT DESIGN

By applying good design practices and value engineering to proposed plans, you can correct poor designs before it's too late.

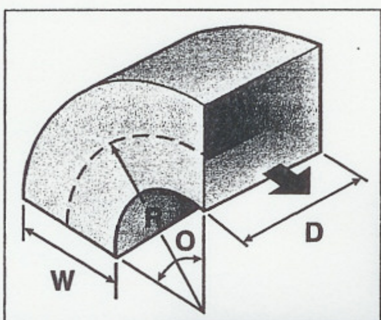
by John H. Stratton

All too often, particularly in the plan & spec arena, design drawings don't reflect elements of good design practices. Some tell-tale signs of poor design include:

- **Dampers to compensate for poorly designed branches.** A good designer knows that pressure loss (from the fan discharge to each outlet, and from fan suction to each inlet) is the same in each pathway. If a duct system is designed properly, excessive dampering shouldn't be necessary.
- **Specifications stating "the most aerodynamically efficient fittings" are to be used in the entire system.** This usually means the designer doesn't know how many elbows it will take to get around obstructions in an uncoordinated design.
- **Specifications stating that fan drives be "changed as necessary."** This often results from a duct system layout based on a 0.1-in. per hundred feet pressure loss and doubling or tripling the aggregate loss in the longest run as a fitting loss additive. This almost always means trouble for the testing and balancing contractor.

Let's look at fitting alternatives available for design or substitution. Specifying a "standard" elbow (one with a centerline radius-to-width (R/W) ratio of 1.5) is not always a good idea in commercial or industrial design. Unfortunately, many designers commonly use this terminology.

For example, according to SMACNA and ASHRAE design tables (**Table 1**), for a Depth-to-Width (D/W) ratio of 0.5, there's a 25% difference in loss Coefficients (C) for rectangular unvaned elbows with centerline R/Ws of 1.5 versus 1.0 (respectively, 0.25 and 0.20).



At a velocity of 1,800 fpm, that's a net increase of 0.01-in. water gage (w.g.). This is a negligible difference considering the second elbow is a much more economical fitting.

What about using a square throat, radius heel elbow? According to SMACNA design tables (not shown), the Velocity Pressures (VP) for 1,000 fpm and 1,800 fpm are respectively, 0.06 and 0.2 in. w.g. According to **Table 1**, the loss Coefficient (C) for a fitting with 0.5 R/W and 0.5 D/W ratios is 1.4. By applying the formula: Fitting losses = C x VP, we find fitting losses are 0.084 in. w.g. at 1,000 fpm and 0.28 in. w.g. at 1,800 fpm. Contrary to popular belief, these are not

Table 1: Loss Coefficient Table for Smooth Radius Rectangular Elbows without Vanes

R/W	Coefficient C										
	D/W										
	0.25	**0.5**	**0.75**	**1.0**	**1.5**	**2.0**	**3.0**	**4.0**	**5.0**	**6.0**	**8.0**
0.5	1.5	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.2
0.75	0.57	0.52	0.48	0.44	0.40	0.39	0.39	0.40	0.42	0.43	0.44
1.0	0.27	0.25	0.23	0.21	0.19	0.18	0.18	0.19	0.20	0.27	0.21
1.5	0.22	0.20	0.19	0.17	0.15	0.14	0.14	0.15	0.16	0.17	0.17
2.0	0.20	0.18	0.16	0.15	0.14	0.13	0.13	0.14	0.14	0.15	0.15

Table 1. For a depth-to-width ratio of 0.5 there's a 25% difference in losses for rectangular unvaned elbows with centerline R/Ws of 1.5 versus 1.0.

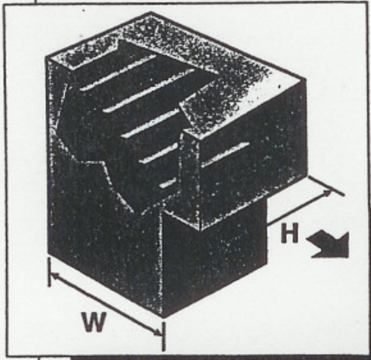
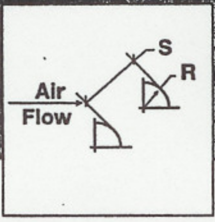


Table 2. Small radius, single thickness, vaned elbows have a loss of about 0.05-in. w.g. from 1,800 fpm on down. Large, single and double-thickness vanes produce about twice as much loss but the number is still fairly low.

Table 2: Loss Coefficient Table for Mitered Rectangular Elbow with Turning Vanes



Loss Coefficients (C) for Single Thickness Vanes

Dimensions, Inches (mm)		Velocity, fpm (m/s)			
		1000	1500	2000	2500
R	S	(5)	(7.5)	(10)	(12.5)
2.0 (50)	1.5 (38)	0.24	0.23	0.22	0.20
4.5 (114)	3.25 (83)	0.26	0.24	0.23	0.22

Loss Coefficients (C) for Double Thickness Vanes

Dimensions, Inches (mm)		Velocity, fpm (m/s)			
		1000	1500	2000	2500
R	S	(5)	(7.5)	(10)	(12.5)
2.0 (50)	1.5 (38)	0.43	0.42	0.41	0.40
2.0 (50)	2.25 (56)	0.53	0.52	0.50	0.49
4.5 (114)	3.25 (83)	0.27	0.25	0.24	0.23

Fitting Loss = C × Vp   Vp = Velocity Pressure (in. w.g.)

banned fittings. Their losses are published in both SMACNA and ASHRAE design manuals.

Based on a limited series of recent SMACNA tests, (the data is in SMACNA's current Duct Design Manual) the losses in 45° throat/square heel, radius throat/square heel, and 45° throat/radius heel elbows, are respectively 0.03-in., 0.026-in., and 0.025-in. w.g. for 1,000 fpm and 0.1-in., 0.09-in. and 0.08-in. w.g. for 1,800 fpm. In many cases, these more economical fittings can substitute for more expensive "ultra-efficient" fittings without negatively affecting the design.

By comparison, small radius, single thickness, vaned elbows have a loss of about 0.05-in. from 1,800 fpm on down. Large, single and double-thickness vanes produce about twice as much loss but the number is still fairly low.

It's a good idea to become familiar with elbows having similar loss coefficients. Compare the loss coefficients in **Tables 1 and 2,** and consider replacing an expensive elbow with a less expensive one with similar losses.

It's important to remember however, that in vaned elbow use, the velocity of approach must be fairly uniform. This is not the case when an elbow is located too close to a fan discharge. Using vaned elbows too close to the fan can result in higher losses than using unvaned elbows. Allow a minimum of 2½ duct diameters of straight duct for air flow to even out at 2,500 fpm or less — more for higher velocities.

The point is you can elbow your way to performance and economy if you take the time to do it right. Always try to place higher loss fittings in branches that require higher losses — and substitute with less expensive fittings that have similar loss coefficients.

Designers who are familiar with the existing database of available information on duct design can use it well. If they don't, you, as a knowledgeable contractor can justify economical substitutions, or at least document the causes of poor performance. CB

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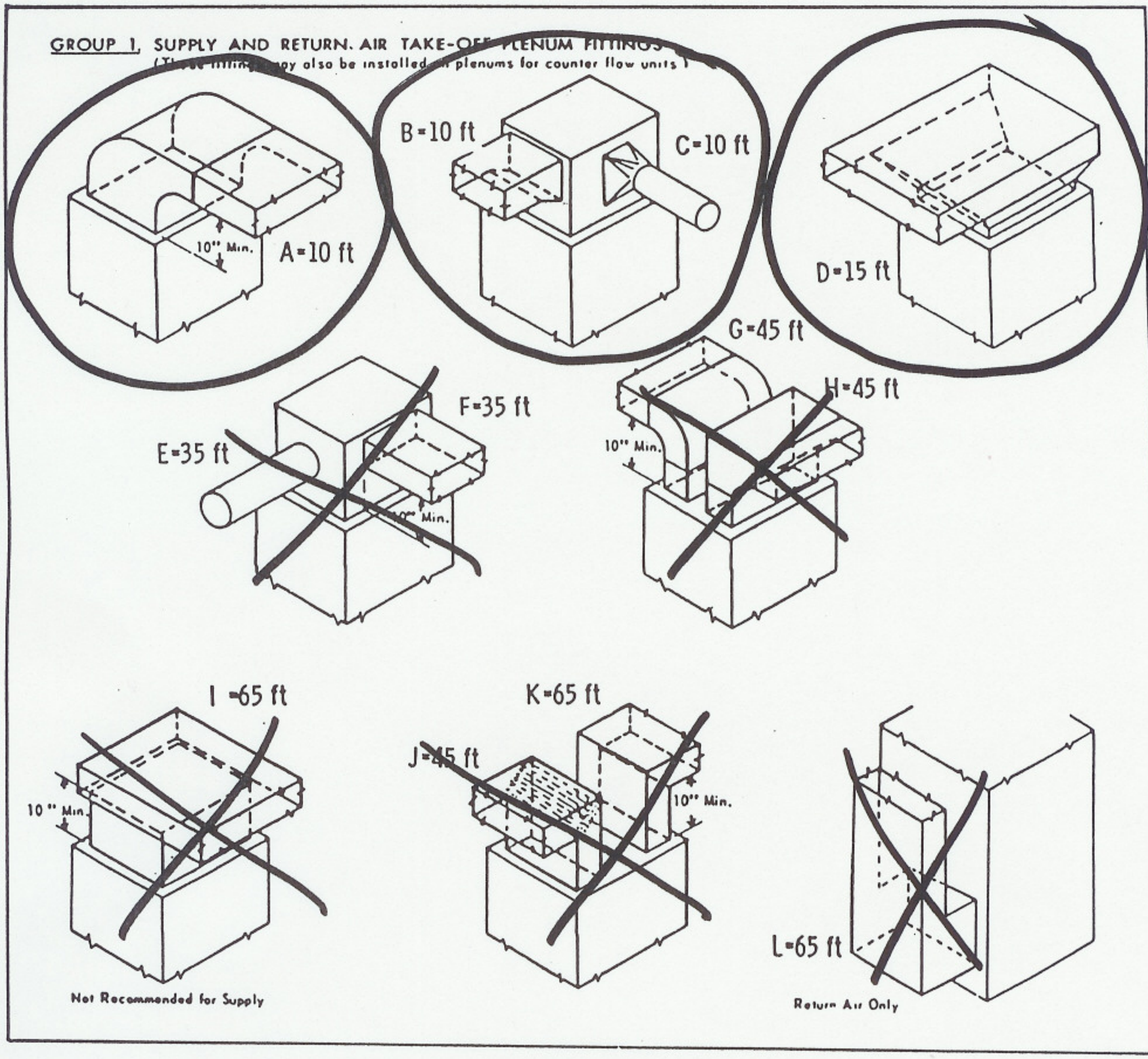

DRAWINGS OF VARIOUS FITTINGS WITH EQUIVLANET LENGTHS SHOWN

20.9: QUICK REFERENCE CAPACITIES OF VARIOUS DUCT SIZE

(Residential Only)

W D	CFM
8 x 8	310
10 x 8	420
12 x 8	500
14 x 8	680
16 x 8	750
18 x 8	850
20 x 8	950
22 x 8	1050
24 x 8	1200
26 x 8	1300
28 x 8	1420
30 x 8	1550

W D	CFM
8 x 10	420
10 x 10	550
12 x 10	700
14 x 10	850
16 x 10	1000
18 x 10	1150
20 x 10	1350
22 x 10	1500
24 x 10	1650
26 x 10	1800
28 x 10	1950
30 x 10	2100

ROUND

DUCT	CFM
4”	35
5”	70
6”	110
7”	165
8”	220
10”	440
12”	600
14”	1100
16”	1500

SQUARE

DUCT	CFM
8 x 8	310
10 x 10	550
12 x 12	900
14 x 14	1350
16 x 16	2000
18 x 18	2400
20 x 20	3500