CAE 464/517 HVAC Systems Design

Spring 2021

March 09, 2021

Air distribution systems: Course project and pressure loss in fittings

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HOMEWORK / PROJECT

RECAP

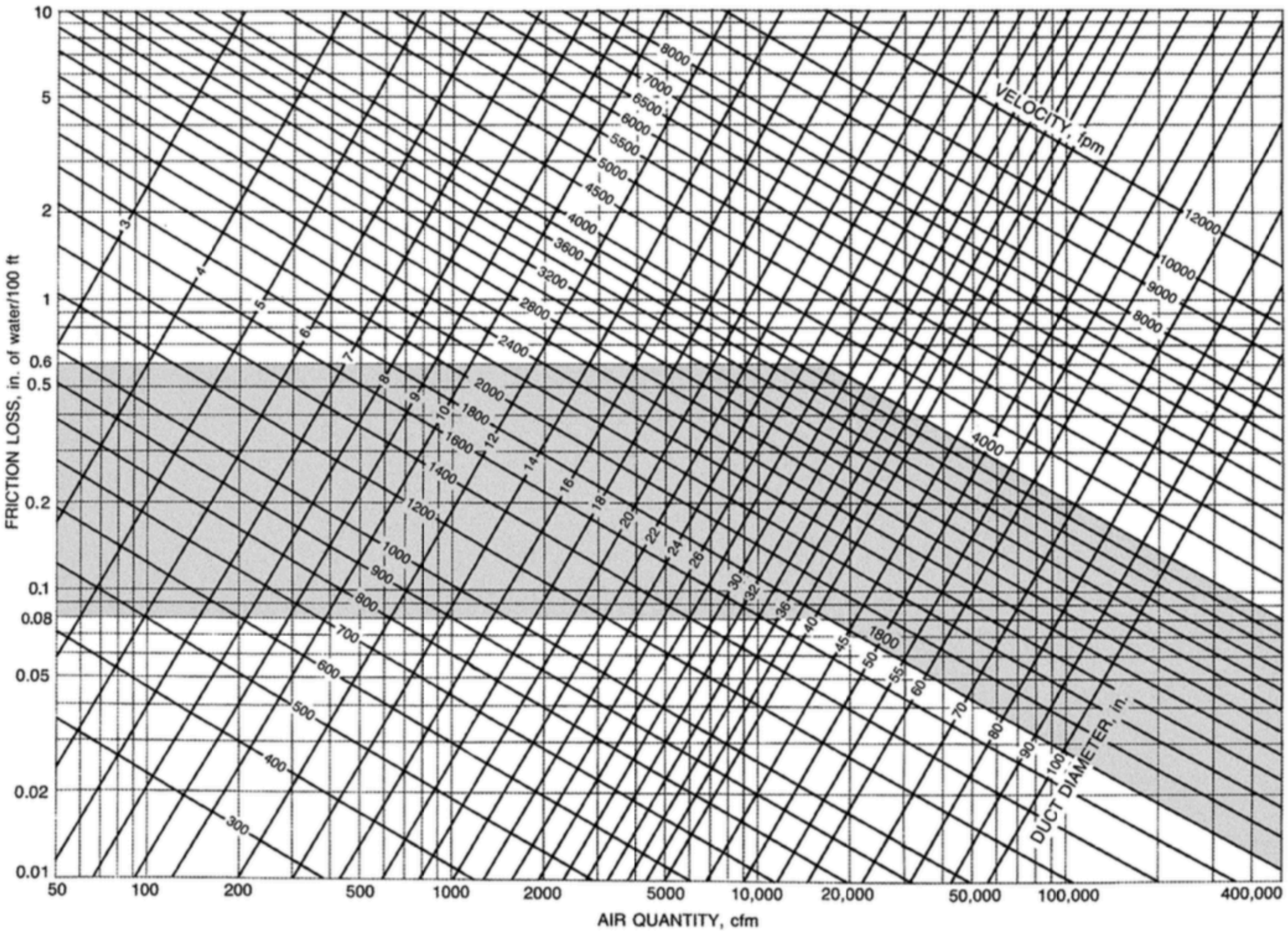
Recap

- We need to consider local friction and duct friction losses together:

$$H_{Lf} = \left[K + f\left(\frac{L}{D}\right)\right]\left(\frac{V^2}{2g}\right)$$

Can we have a simplified version for friction loss in ductwork?

Recap



FRICTION LOSS, in. of water/100 ft
AIR QUANTITY, cfm
VELOCITY, fpm
DUCT DIAMETER, in.
10
5
2
1
0.6
0.5
0.2
0.1
0.08
0.05
0.02
0.01
50
100
200
500
1000
2000
5000
10,000
20,000
50,000
100,000
400,000

Recap

- We define circular equivalent of rectangular ducts as:

$$D_e = 1.30 \frac{(ab)^{0.625}}{(a+b)^{0.25}}$$

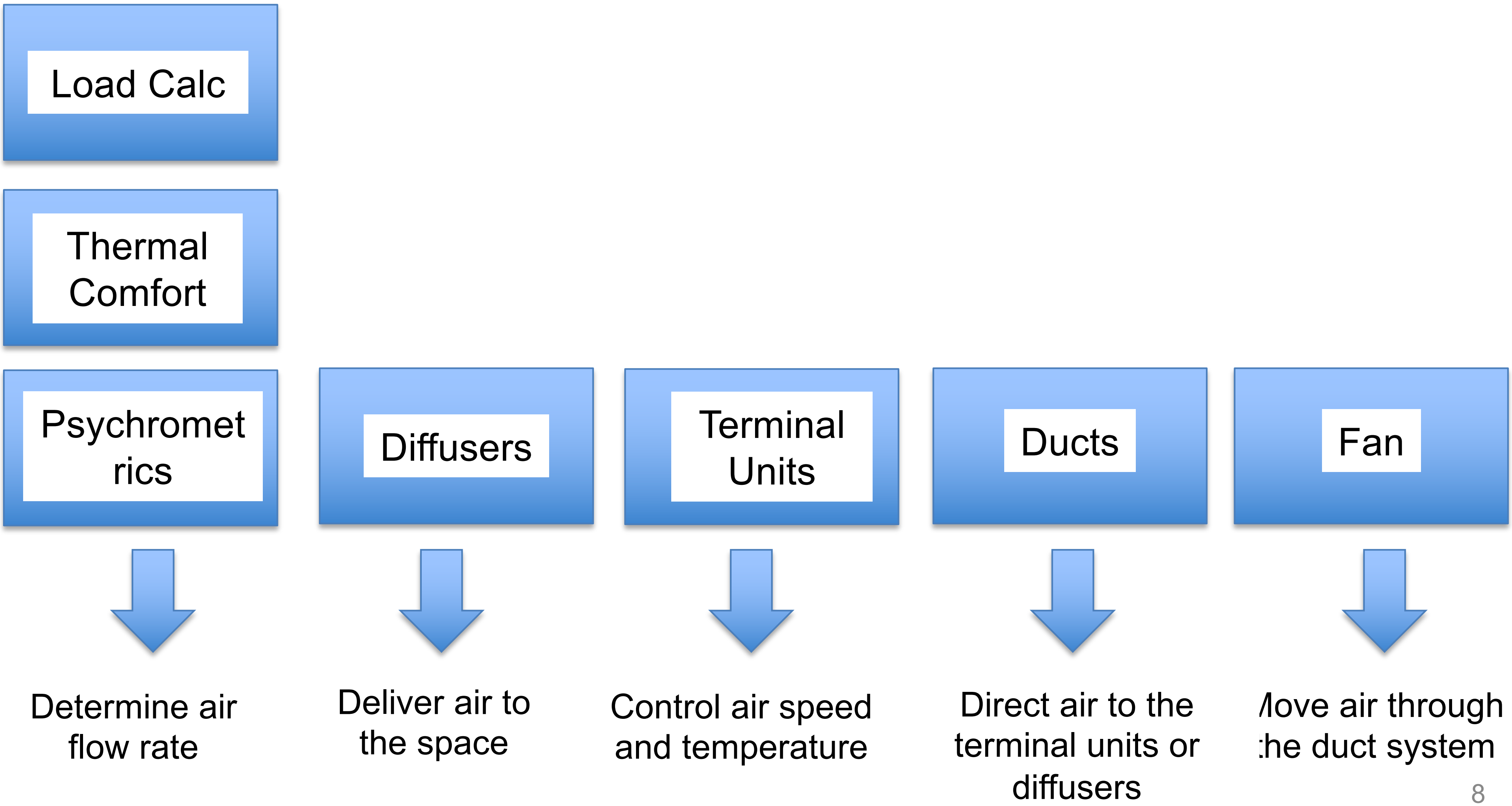
- Where:
    - ❑ D_e: Circular equivalent of a rectangular duct (in)
    - ❑ a: Height of duct (in)
    - ❑ b: Width of duct (in)

Recap

Circular Duct Diameter, in.	Length of One Side of Rectangular Duct (*a*), in.																			
	4	5	6	7	8	9	10	12	14	16	18	20	22	24	26	28	30	32	34	36
	Length Adjacent Side of Rectangular Duct (*b*), in.																			
5	5																			
5.5	6	5																		
6	8	6																		
6.5	9	7	6																	
7	11	8	7																	
7.5	13	10	8	7																
8	15	11	9	8																
8.5	17	13	10	9																
9	20	15	12	10	8															
9.5	22	17	13	11	9															
10	25	19	15	12	10	9														
10.5	29	21	16	14	12	10														
11	32	23	18	15	13	11	10													
11.5		26	20	17	14	12	11													
12		29	22	18	15	13	12													
12.5		32	24	20	17	15	13													
13		35	27	22	18	16	14	12												
13.5		38	29	24	20	17	15	13												
14			32	26	22	19	17	14												
14.5			35	28	24	20	18	15												
15			38	30	25	22	19	16	14											
16			45	36	30	25	22	18	15											
17				41	34	29	25	20	17	16										
18				47	39	33	29	23	19	17										
19				54	44	38	33	26	22	19	18									
20					50	43	37	29	24	21	19									
21					57	48	41	33	27	23	20									

Recap

- There are a couple of components required for the design of an air distribution



PRESSURE LOSS IN FITTINGS

Pressure Loss in Fittings

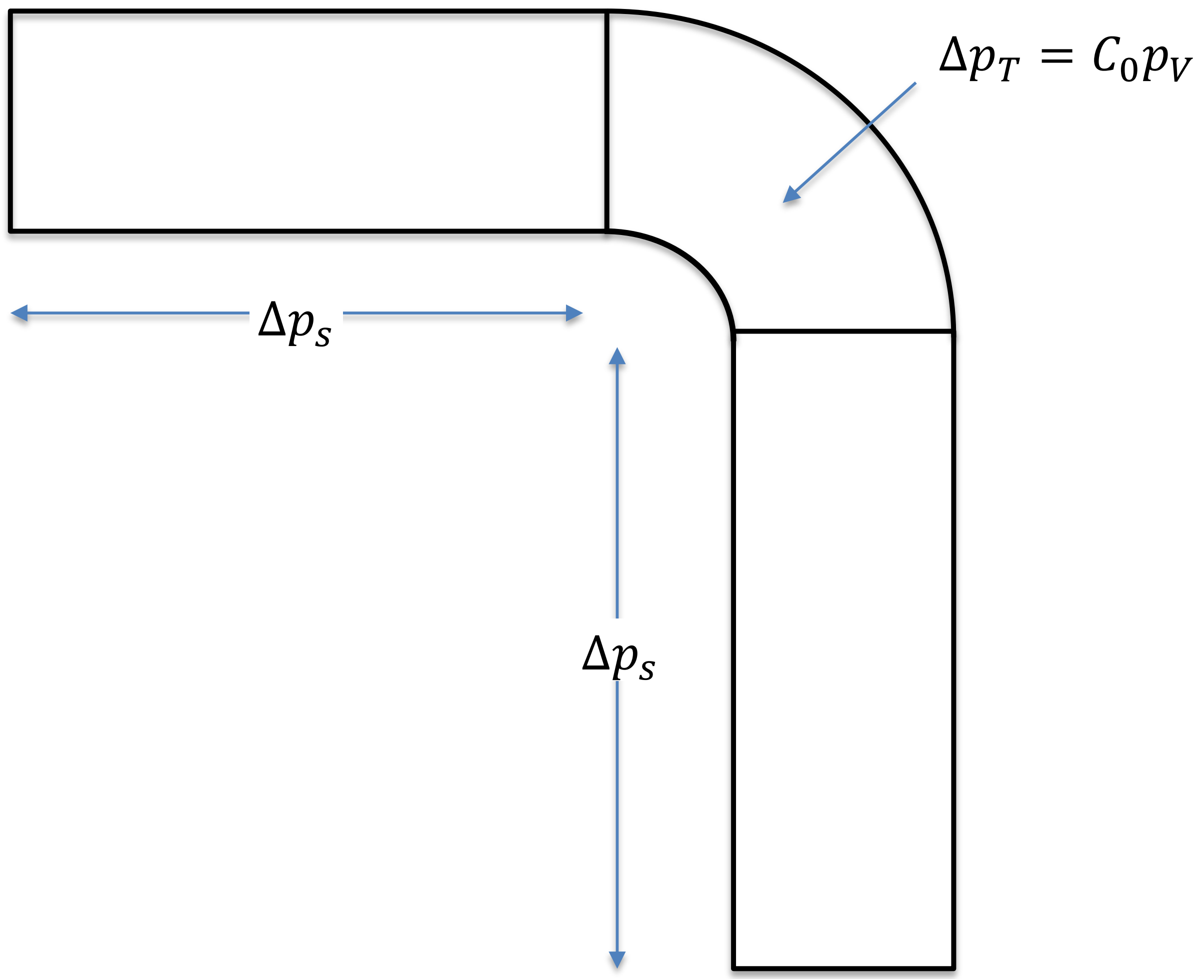
- For all fittings except junctions, the pressure loss in a fitting can be written as

$$\Delta p_{total} = C_o \, p_{v,0}$$

  - ❑ C_o: Local loss coefficient of fitting (dimensionless)
  - ❑ Δp_{total}: Fitting total pressure loss (in w.c.)
  - ❑ $p_{v,o}$: Velocity pressure at section “o" of fitting (in w.c.)
  - ❑ $p_{v,o} = \left(\frac{V_o}{4{,}005}\right)^2$
  - ❑ V_o: Velocity in section of fitting

Pressure Loss in Fittings

- Pressure drop calculations (elbows and transitions)



Pressure Loss in Fittings

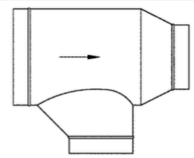
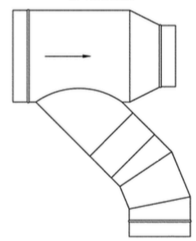
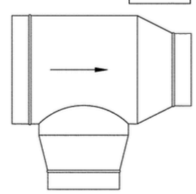
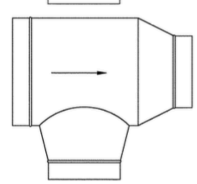
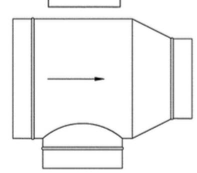
$$p_{v,o} = \left(\frac{V_o}{4{,}005}\right)^2$$

Duct velocity V_o (fpm)	Duct pressure p_v (in w.c.)
4,000	1.00
3,000	0.56
2,000	0.25
1,000	0.06

Pressure Loss in Fittings

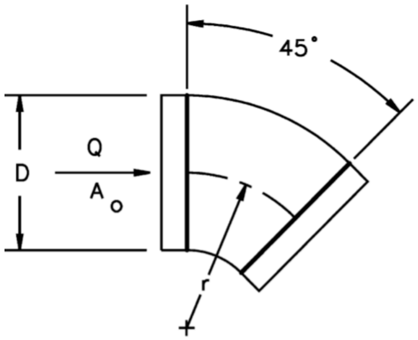
- Pressure drop calculations for converging and diverging fittings are documents in the Handbook:

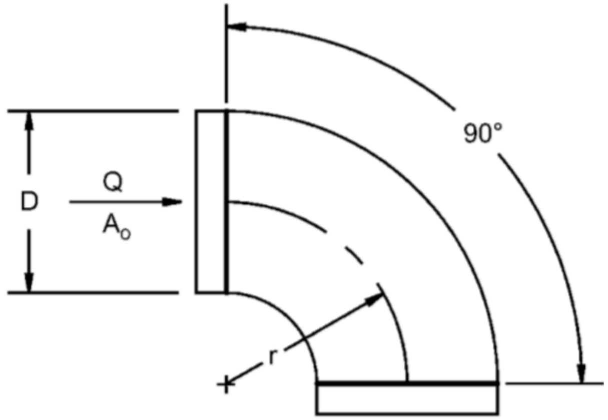
Table 10 Options for Selecting 90° Takeoff

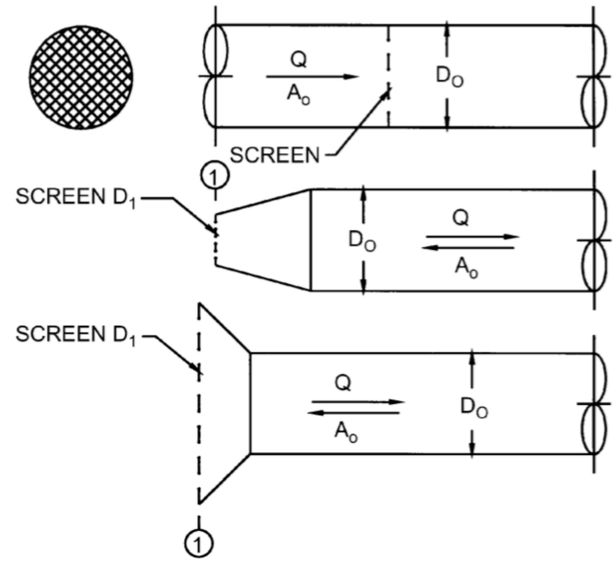
Code	Description		Efficiency	Loss Coefficient	
				Main[a]	Branch[b]
SD5-12	Tee, 45° entry branch		Highest	0.15	0.64
SD5-4	Wye, 45°, Straight body branch with 45° elbow, 90° to main		—	0.15	0.74
SD5-11	Tee, Conical branch		—	0.15	0.87
SD5-10	Tee, Conical branch tapered into body		—	0.15	1.10
SD5-9	Tee		Lowest	0.15	1.80

[a] $Q_s/Q_c = 0.8$; $A_s/A_c = 0.69$
[b] $Q_b/Q_c = 0.2$; $A_b/A_c = 0.25$

Pressure Loss in Fittings



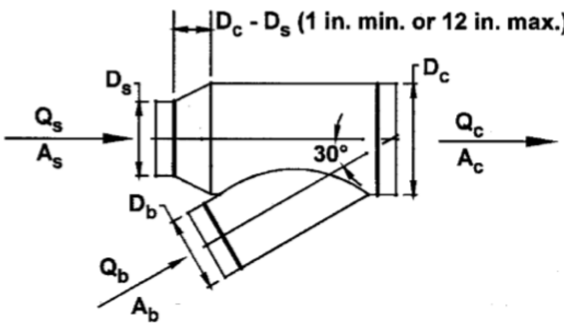


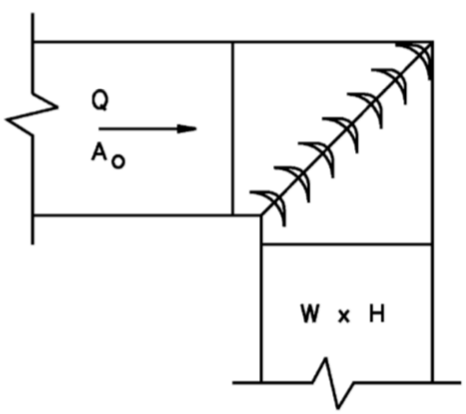


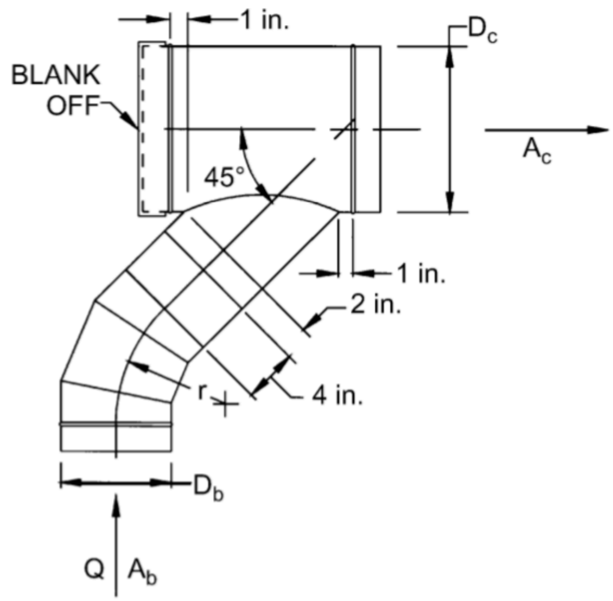
n = free area ratio of screen

A_o = area of duct

A_1 = cross-sectional area of duct or fitting where screen is located

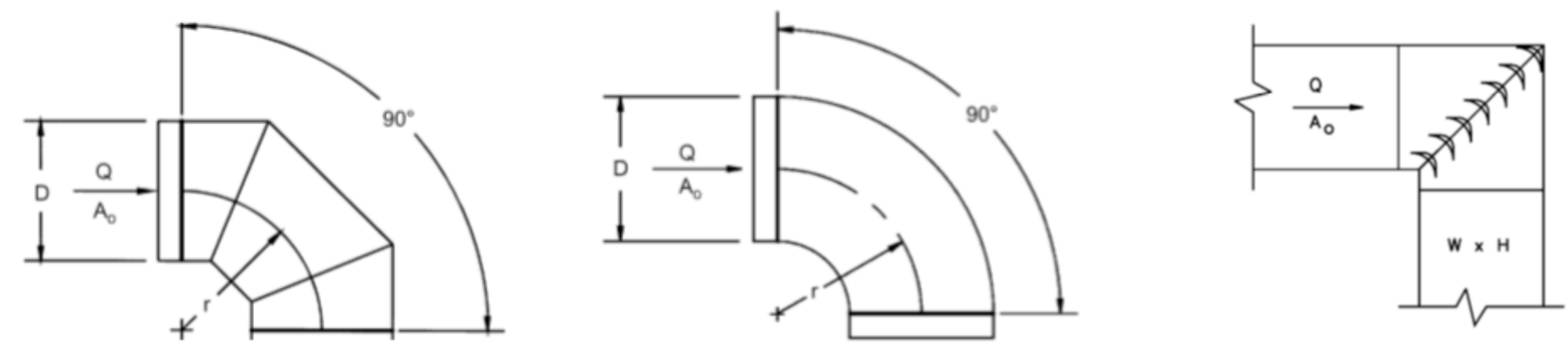






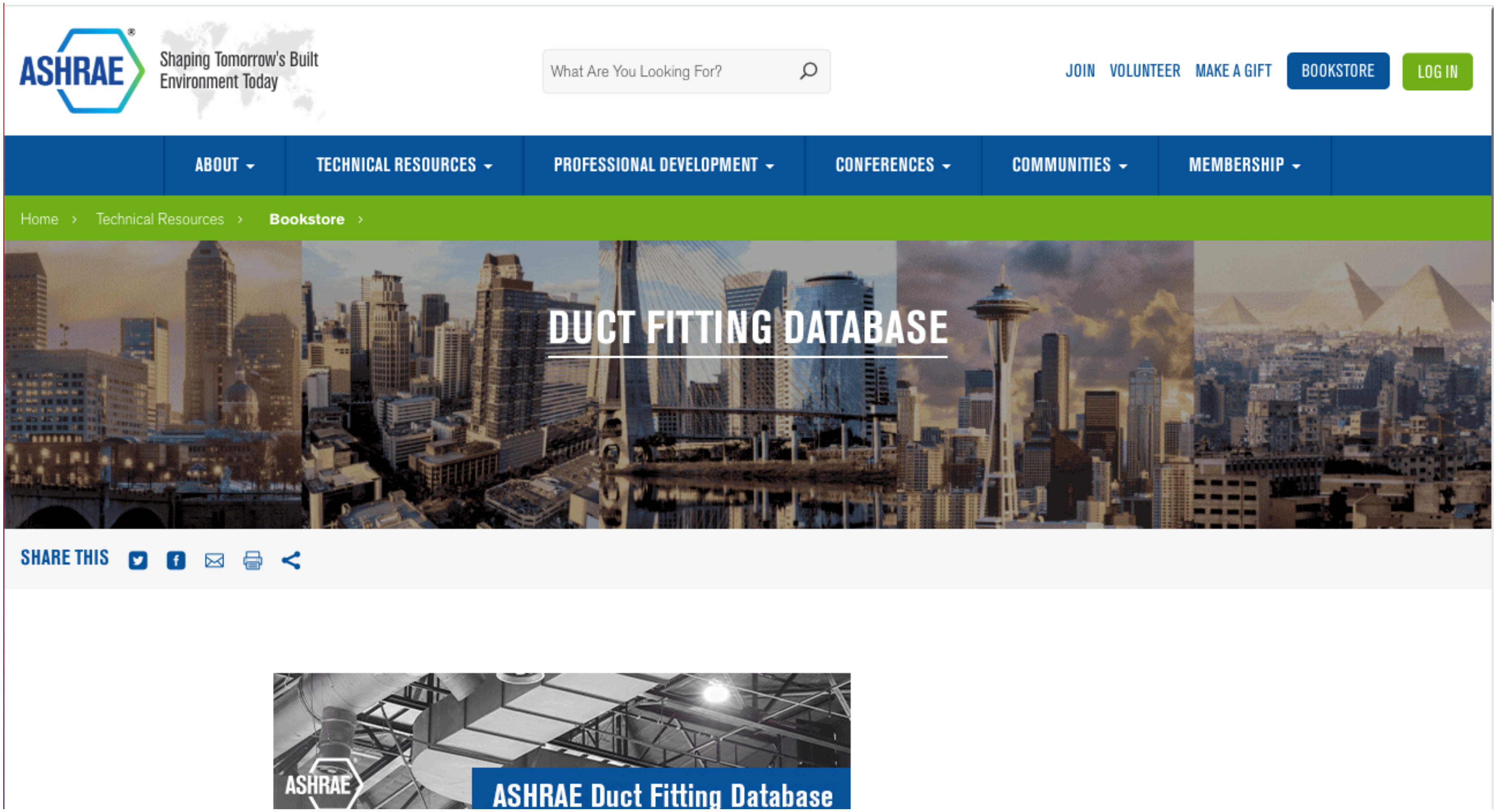
Pressure Loss in Fittings

- Local loss coefficient in elbow is a function of:
  - ❑ Turning angle of elbow
  - ❑ Relative radius of curvature of throat radius to width of duct
  - ❑ Installation of vanes
  - ❑ Shape of the cross section of the duct



Pressure Loss in Fittings

- ASHRAE or SMACNA have different apps and documents for providing these losses



https://www.ashrae.org/technical-resources/bookstore/duct-fitting-database

Pressure Loss in Fittings

- You can use other resources (e.g., Chapter 8 of the Price Industries Handbook)
- Older version of ASHRAE Handbook

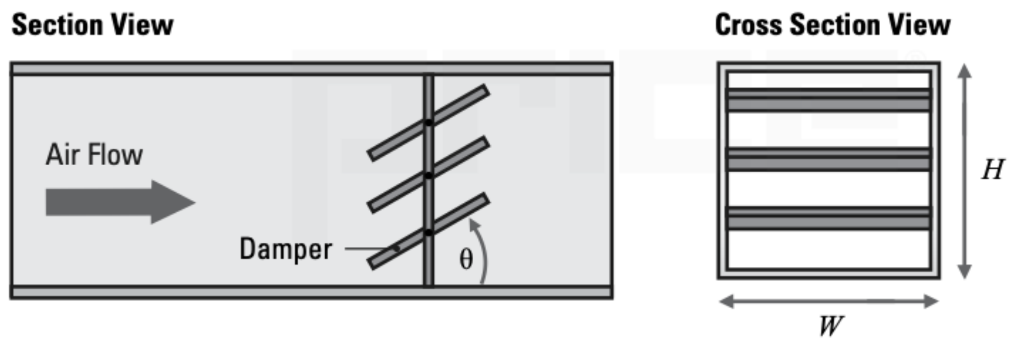
https://utahashrae.org/images/meeting/011119/Slides/smacna_duct_design_fundamentals.pdf

http://ftp.demec.ufpr.br/disciplinas/TM184/VENTILACAO_LOCAL_EXAUSTORA/DUCT_DESIGN.pdf

Pressure Loss in Fittings

- Dampers (e.g., parallel blade):

$$C_0 = \frac{\Delta p_0}{p_v}$$



Coefficient *C*

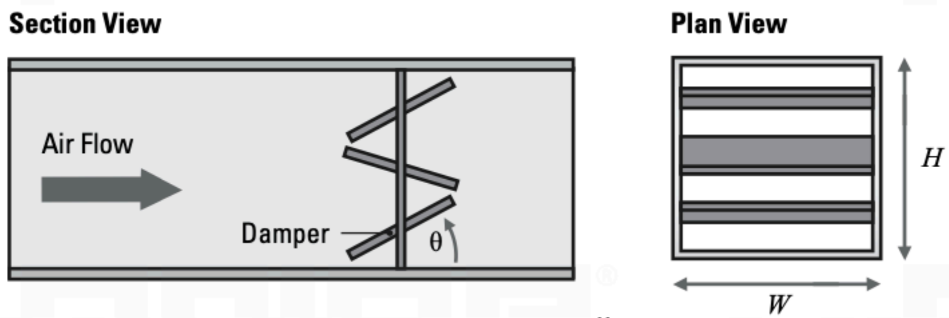
L/R	θ								
	80°	70°	60°	50°	40°	30°	20°	10°	0° fully open
0.3	116	32	14	9.0	5.0	2.3	1.4	0.79	0.52
0.4	152	38	16	9.0	6.0	2.4	1.5	0.85	0.52
0.5	188	45	18	9.0	6.0	2.4	1.5	0.92	0.52
0.6	245	45	21	9.0	5.4	2.4	1.5	0.92	0.52
0.8	284	55	22	9.0	5.4	2.5	1.5	0.92	0.52
1.0	361	65	24	10	5.4	2.6	1.6	1.0	0.52
1.5	576	102	28	10	5.4	2.7	1.6	1.0	0.52

Price Industries Engineering Handbook

Pressure Loss in Fittings

- Dampers (e.g., opposed blade):

$$C_0 = \frac{\Delta p_0}{p_v}$$



Abrupt Exit - Coefficient *C*									
L/R	θ								
	80°	70°	60°	50°	40°	30°	20°	10°	0° fully open
0.3	807	284	73	21	9.0	4.1	2.1	0.85	0.52
0.4	915	332	100	28	11	5.0	2.2	0.92	0.52
0.5	1045	377	122	33	13	5.4	2.3	1.0	0.52
0.6	1121	411	148	38	14	6.0	2.3	1.0	0.52
0.8	1299	495	188	54	18	6.6	2.4	1.1	0.52
1.0	1521	547	245	65	21	7.3	2.7	1.2	0.52
1.5	1654	677	361	107	28	9.0	3.2	1.4	0.52

$$\frac{L}{R} = \frac{NW}{2(H+W)}$$

Price Industries Engineering Handbook

Pressure Loss in Fittings

- Supply outlets (from the same performance data tables):

PDF/PDN/PDC/PDMC/PDSP

Perforated Face Supply Diffuser

PERFORMANCE DATA

PDF/PDFE - 16 in. x 16 in.

Inlet Size	Neck Velocity (fpm) / Velocity Pressure (in. w.g.)		300 / .006	400 / .010	500 / .016	600 / .022	700 / .031	800 / .040	900 / .050	1000 / .062	1200 / .090	1400 / .122
6 Ø	Total Pressure (in. w.g.)		.012	.021	.033	.047	.064	.084	.106	.131	.189	.257
	Flow Rate (cfm)		59	78	98	118	137	157	176	196	235	274
	Sound (NC)		-	-	-	19	24	28	32	35	41	46
	Throw (ft.)	4 Way	0-1-4	1-2-6	1-3-7	2-4-8	3-5-9	4-6-10	4-7-10	5-7-11	6-8-12	7-9-13
		3 Way	1-1-5	1-2-7	2-4-9	2-5-10	3-6-11	4-7-11	5-8-12	6-9-13	7-10-14	8-11-15
		2 Way	1-2-7	1-3-10	2-5-12	3-7-13	4-8-14	6-10-15	7-11-16	8-12-17	10-13-19	11-14-20
		1 Way	1-2-9	2-4-12	3-6-15	4-9-17	5-10-18	7-12-19	9-13-20	10-15-21	12-17-23	14-18-25
6 x 6	Total Pressure (in. w.g.)		.013	.024	.037	.054	.073	.096	.121	.150	.215	.293
	Flow Rate (cfm)		75	100	125	150	175	200	225	250	300	350
	Sound (NC)		-	-	17	22	27	31	35	38	44	48
	Throw (ft.)	4 Way	1-1-5	1-2-7	2-4-9	2-5-9	3-6-10	4-7-11	5-8-11	6-9-12	7-9-13	8-10-14
		3 Way	1-2-6	1-3-8	2-5-10	3-6-11	4-7-12	5-8-13	6-9-14	7-10-14	8-11-16	10-12-17
		2 Way	1-2-8	2-4-11	3-6-14	4-8-15	5-10-16	7-11-17	8-13-18	9-14-19	11-15-21	13-16-23
		1 Way	1-3-11	2-5-14	3-8-17	5-11-19	7-12-20	9-14-22	11-16-23	12-17-24	14-19-26	16-20-29
8 Ø	Total Pressure (in. w.g.)		.017	.029	.046	.066	.090	.118	.149	.184	.265	.360
	Flow Rate (cfm)		105	140	175	209	244	279	314	349	419	489
	Sound (NC)		-	-	21	26	31	35	39	42	48	52
	Throw (ft.)	4 Way	1-2-7	2-3-9	2-5-10	3-7-11	5-8-12	6-9-13	7-10-14	7-10-14	9-11-16	10-12-17
		3 Way	1-2-8	2-4-11	3-7-12	4-8-13	6-9-14	7-11-15	8-11-16	9-12-17	11-13-19	12-14-20
		2 Way	1-3-11	2-6-14	4-9-16	6-11-18	8-12-19	9-14-20	11-15-22	12-16-23	14-18-25	16-19-27
		1 Way	2-4-13	3-7-18	5-11-20	7-13-22	10-15-24	12-18-26	13-19-27	15-20-29	18-22-31	19-24-34
	Total Pressure (in. w.g.)		.019	.034	.053	.076	.104	.136	.172	.212	.305	.415

Can you calculate the static and dynamic pressure drops?

https://www.priceindustries.com/content/uploads/assets/literature/catalogs/performance-data/section%20c/pdf-perforated-face-supply-diffuser-performance-data.pdf

Pressure Loss in Fittings

- Any other components in the duct system to consider?
  - ❑ Heating coil
  - ❑ Cooling coil
  - ❑ Outdoor air louvers

Pressure Loss in Fittings

- Although they often account for a major portion of the total pressure loss, the additional losses due to entries and exits, fittings and dampers are traditionally referred to as minor losses

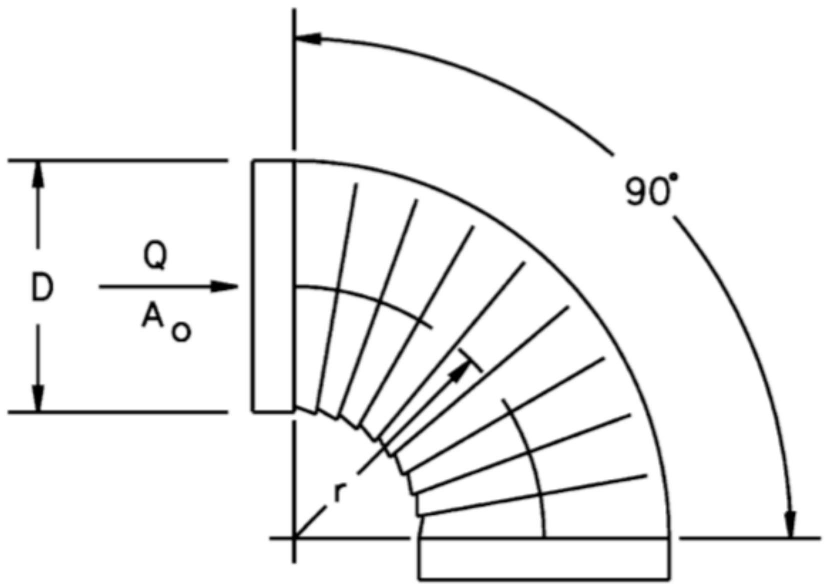
- These losses represent additional energy dissipation in the flow, usually caused by secondary flows induced by curvature or recirculation

- The minor losses are any total pressure loss present in addition to the total pressure loss for the same length of straight pipe

CLASS ACTIVITY

Class Activity

- Problem:
  - Compute the lost pressure in a 6 in, 90-degree plated elbow that has 150 cfm of airflow through it
  - The ratio of turning radius to diameter is 1.5



CD3-5 Elbow, Pleated, 90 Degree, $r/D = 1.5$

D, in.	4	6	8	10	12	14	16
C_o	0.57	0.43	0.34	0.28	0.26	0.25	0.25

Class Activity

- Solution (IP Unit):

CD3-5 Elbow, Pleated, 90 Degree, $r/D = 1.5$

D, in.	4	6	8	10	12	14	16
C_o	0.57	0.43	0.34	0.28	0.26	0.25	0.25

- Calculate velocity

$$V = \frac{Q}{A} = \frac{Q}{\left(\frac{\pi}{4}\right) D^2} = \frac{150 \times 4 \times 144}{\pi \times 36} = 764\ fpm$$

Class Activity

- Calculate pressure (IP Unit):

$$p_v = \left(\frac{V}{4{,}005}\right)^2 = \left(\frac{746}{4{,}005}\right)^2 = 0.036\ in\ w.c.$$

- Calculate fitting total pressure loss:

$$p_T = C_0 p_v = 0.43 \times 0.036 = 0.016\ in\ w.c.$$

Class Activity

- Solution (SI Unit):

CD3-5 Elbow, Pleated, 90 Degree, $r/D = 1.5$

D, in.	4	6	8	10	12	14	16
C_o	0.57	0.43	0.34	0.28	0.26	0.25	0.25

- Calculate velocity

$$V = \frac{Q}{A} = \frac{Q}{\left(\frac{\pi}{4}\right) D^2} = \frac{(4.25\,\frac{m^3}{min})\times 4}{\pi\times(0.1524)^2(60\,\frac{s}{min})} = 3.88\,\frac{m}{s}$$

- Calculate pressure

$$p_v = \left(\frac{V}{1.29}\right)^2 = \left(\frac{3.88}{1.29}\right)^2 = 3.89\ Pa$$

$$p_T = C_0 p_v = 0.43\times 3.89 = 1.627\ Pa$$

DESIGN RULES

Design Rules

- The most important is that the duct fitting loss is a function of the velocity pressure in the duct, and that duct velocity pressure is a function of the square of the flow rate:

  - In practical terms, it means that the pressure losses associated with a poor fitting in a low velocity duct system will be much less than the losses associated with the same fitting in a higher velocity duct system

Design Rules

- A second important rule is that the ratio of perimeter to cross sectional area for a large duct is generally much smaller than it is for a small duct:
  - In practical terms, the velocities in a large duct will be much higher than they are in a smaller duct when designed at equal friction rates
  - As a result, the potential for a poor fitting to cause a static pressure problem is much higher in the larger ducts associated with an air handling system

Design Rules

- Some common fitting terminology are:

Fitting Function	Geometry	Category	Sequential Number
S: **S**upply	D: Round (**D**iameter)	1. Entries	1, 2, 3, …
		2. Exits	
E: **E**xhaust / Return	R: **R**ectangular	3. Elbows	
		4. Transitions	
C: **C**ommon (supply/ return)	F: **F**lat oval	5. Junctions	
		6. Obstructions	
		7. Fan and system interactions	
		8. Duct-mounted equipment	
		9. Dampers	
		10. Hoods	

Design Rules

- A few items to consider are:
  - ❑ Space pressure relationships
  - ❑ Fire and smoke control
  - ❑ Duct insulation
  - ❑ Duct system leakage
  - ❑ System and duct noise
  - ❑ Testing and balancing

Design Rules

- See Table 12 for the recommended maximum airflow velocities:

Table 12 Recommended Maximum Airflow Velocities to Achieve Specified Acoustic Design Criteria*

Duct Location	NC or RC Rating in Adjoining Occupancy	Maximum Airflow Velocity, fpm	
		Rectangular Duct	Round Duct
1	2	3	4
In shaft or above solid drywall ceiling	45	3500	5000
	35	2500	3500
	25 or less	1500	2500
Above suspended acoustical ceiling	45	2500	4500
	35	1750	3000
	25 or less	1000	2000
Duct within occupied space	45	2000	3900
	35	1450	2600
	25 or less	950	1700

Design Rules

- Look at Table 9 for different design criterion for recommended duct velocity and diameter:

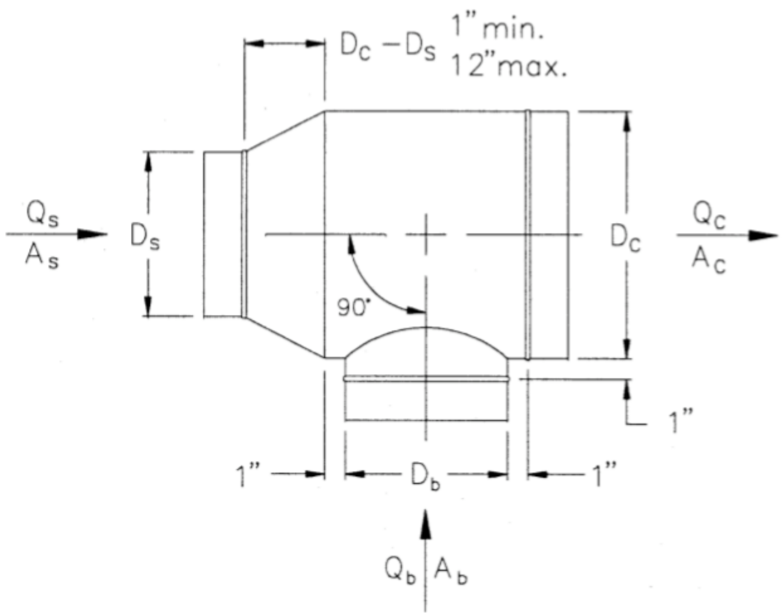
Table 9 Maximum Airflow of Round, Flat Oval and Rectangular Ducts as Function of Available Ceiling Space

A. Design Criterion: 0.08 in. of water per 100 ft or 2500 fpm Maximum						
Minimum Clearance for Duct, in.	**18**	**22**	**26**	**30**	**34**	**38**
Single Round Duct						
Duct diameter, in.	14	18	22	26	30	34
Airflow, cfm	950	1900	3200	4900	7300	10,000
Velocity, fpm	889	1075	1212	1329	1487	1586
Rectangular Duct with Aspect Ratio = 2						
Rectangular $W \times H$, in.	28 × 14	36 × 18	44 × 22	52 × 26	60 × 30	68 × 34
Airflow, cfm	2900	5500	9800	14,900	21,200	30,000
Velocity, fpm	1065	1222	1458	1587	1696	1869
Equivalent diameter D_e, in.	21.3	27.4	33.5	39.6	45.7	51.8
Flat Oval Duct with Aspect Ratio = 2						
Flat oval $A \times a$, in.	28 × 14	36 × 18	44 × 22	52 × 26	60 × 30	68 × 34
Airflow, cfm	2700	5400	9000	14,000	21,000	28,000
Velocity, fpm	1111	1344	1500	1670	1882	1954
Equivalent diameter D_e, in.	20.7	26.6	32.5	38.4	44.4	50.3
Two Round Ducts in Parallel						
Duct diameter, in.	Two 12	Two 16	Two 20	Two 24	Two 28	Two 32
Airflow, cfm	630 each	1350 each	2450 each	3950 each	5950 each	8500 each
Velocity, fpm	802	967	1123	1257	1391	1522

EXAMPLE

Example

- **Example:** Compute the loss in total pressure for a round 90-dgree branch and straight-through section, a tee. The common section is 12 in. in diameter, and the straight-through section has a 10 in. diameter with a flow rate of 1,100 cfm. The branch flow rate is 250 cfm through a 6 in. duct.



	C_b Values								
	Q_b/Q_c								
A_b/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	1.20	0.62	0.80	1.28	1.99	2.92	4.07	5.44	7.02
0.2	4.10	1.20	0.72	0.62	0.66	0.80	1.01	1.28	1.60
0.3	8.99	2.40	1.20	0.81	0.66	0.62	0.64	0.70	0.80
0.4	15.89	4.10	1.94	1.20	0.88	0.72	0.64	0.62	0.63
0.5	24.80	6.29	2.91	1.74	1.20	0.92	0.77	0.68	0.63
0.6	35.73	8.99	4.10	2.40	1.62	1.20	0.96	0.81	0.72
0.7	48.67	12.19	5.51	3.19	2.12	1.55	1.20	0.99	0.85
0.8	63.63	15.89	7.14	4.10	2.70	1.94	1.49	1.20	1.01
0.9	80.60	20.10	8.99	5.13	3.36	2.40	1.83	1.46	1.20

	C_s Values								
	Q_s/Q_c								
A_s/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	0.13	0.16							
0.2	0.20	0.13	0.15	0.16	0.28				
0.3	0.90	0.13	0.13	0.14	0.15	0.16	0.20		
0.4	2.88	0.20	0.14	0.13	0.14	0.15	0.15	0.16	0.34
0.5	6.25	0.37	0.17	0.14	0.13	0.14	0.14	0.15	0.15
0.6	11.88	0.90	0.20	0.13	0.14	0.13	0.14	0.14	0.15
0.7	18.62	1.71	0.33	0.18	0.16	0.14	0.13	0.15	0.14
0.8	26.88	2.88	0.50	0.20	0.15	0.14	0.13	0.13	0.14
0.9	36.45	4.46	0.90	0.30	0.19	0.16	0.15	0.14	0.13

Example

- Solution:

- Calculate velocity in each section:

$$V_c = \frac{Q_c}{A_c} = \frac{Q_c}{\left(\frac{\pi}{4}\right) D_c^2} = \frac{1{,}100}{\frac{\pi}{4} \times \left(\frac{12}{12}\right)^2} = 1{,}400\ fpm$$

$$V_b = \frac{Q_b}{A_b} = \frac{Q_b}{\left(\frac{\pi}{4}\right) D_b^2} = \frac{250}{\frac{\pi}{4} \times \left(\frac{6}{12}\right)^2} = 1{,}273\ fpm$$

$$V_s = \frac{Q_s}{A_s} = \frac{Q_s}{\left(\frac{\pi}{4}\right) D_s^2} = \frac{850}{\frac{\pi}{4} \times \left(\frac{10}{12}\right)^2} = 1{,}558\ fpm$$

Example

- Solution:

- The ratio of the branch to the common flow rate is:

$$\frac{Q_b}{Q_c} = \frac{250}{1{,}100} = 0.23$$

- The ratio of the main to the common flow rate is:

$$\frac{Q_s}{Q_c} = \frac{850}{1{,}100} = 0.77$$

Example

- Solution:

- The ratio of the branch to the common are is:

$$\frac{A_b}{A_c} = \left(\frac{6}{12}\right)^2 = 0.25$$

- The ratio of the main to the common are is:

$$\frac{A_s}{A_c} = \left(\frac{10}{12}\right)^2 = 0.69$$

Example

- Solution:

- Using the loss coefficient for the branch, we have

$$\Delta p_{0b} = C_b \left(\frac{V_b}{4{,}005}\right)^2 = 1.55 \left(\frac{1{,}273}{4{,}005}\right)^2 = 0.16\ in\ w.c.$$

$$\frac{A_b}{A_c} = 0.25$$

$$\frac{Q_b}{Q_c} = 0.23$$

	C_b Values								
	Q_b/Q_c								
A_b/A_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	1.20	0.62	0.80	1.28	1.99	2.92	4.07	5.44	7.02
0.2	4.10	1.20	0.72	0.62	0.66	0.80	1.01	1.28	1.60
0.3	8.99	2.40	1.20	0.81	0.66	0.62	0.64	0.70	0.80
0.4	15.89	4.10	1.94	1.20	0.88	0.72	0.64	0.62	0.63
0.5	24.80	6.29	2.91	1.74	1.20	0.92	0.77	0.68	0.63
0.6	35.73	8.99	4.10	2.40	1.62	1.20	0.96	0.81	0.72
0.7	48.67	12.19	5.51	3.19	2.12	1.55	1.20	0.99	0.85
0.8	63.63	15.89	7.14	4.10	2.70	1.94	1.49	1.20	1.01
0.9	80.60	20.10	8.99	5.13	3.36	2.40	1.83	1.46	1.20

Example

- Solution:

- Using the loss coefficient for the branch, we have

$$\Delta p_{0s} = C_s \left(\frac{V_s}{4{,}005}\right)^2 = 0.14 \left(\frac{1{,}558}{4{,}005}\right)^2 = 0.021\ in\ w.c.$$

$$\frac{A_s}{A_c} = 0.69$$

$$\frac{Q_s}{Q_c} = 0.77$$

C_s Values

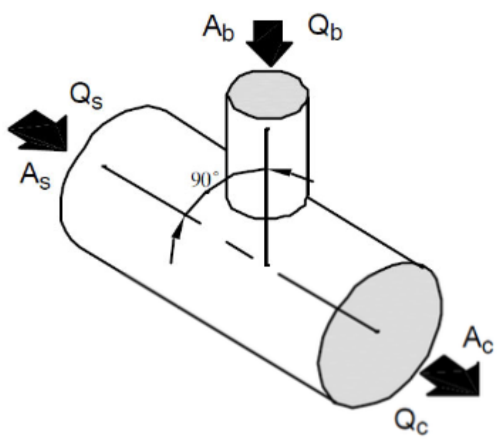
	Q_s/Q_c								
A_s/A_c	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
0.1	0.13	0.16							
0.2	0.20	0.13	0.15	0.16	0.28				
0.3	0.90	0.13	0.13	0.14	0.15	0.16	0.20		
0.4	2.88	0.20	0.14	0.13	0.14	0.15	0.15	0.16	0.34
0.5	6.25	0.37	0.17	0.14	0.13	0.14	0.14	0.15	0.15
0.6	11.88	0.90	0.20	0.13	0.14	0.13	0.14	0.14	0.15
0.7	18.62	1.71	0.33	0.18	0.16	0.14	0.13	0.15	0.14
0.8	26.88	2.88	0.50	0.20	0.15	0.14	0.13	0.13	0.14
0.9	36.45	4.46	0.90	0.30	0.19	0.16	0.15	0.14	0.13

EXAMPLE

Example

- Example: Converging Tee 90° Round Main and Branch. Main is 10”, Branch is 7”. Air flow Main is 1000 cfm. Air flow Branch is 500 cfm.

B. CONVERGING TEE, 90°, ROUND



Branch, Coefficient C (*See* Note 8)							
Q_b/Q_c	A_b/A_c						
	0.1	0.2	0.3	0.4	0.6	0.8	1.0
0.1	0.40	-0.37	-0.51	-0.46	-0.50	-0.51	-0.52
0.2	3.8	0.72	0.17	-0.02	-0.14	-0.18	-0.24
0.3	9.2	2.3	1.0	0.44	0.21	0.11	-0.08
0.4	16	4.3	2.1	0.94	0.54	0.40	0.32
0.5	26	6.8	3.2	1.1	0.66	0.49	0.42
0.6	37	9.7	4.7	1.6	0.92	0.69	0.57
0.7	43	13	6.3	2.1	1.2	0.88	0.72
0.8	65	17	7.9	2.7	1.5	1.1	0.86
0.9	82	21	9.7	3.4	1.8	1.2	0.99
1.0	101	26	12	4.0	2.1	1.4	1.1

Main, Coefficient C (*See* Note 8)										
Q_b/Q_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
C	0.16	0.27	0.38	0.46	0.53	0.57	0.59	0.60	0.59	0.55

Example

- Solution

$$A_c = \frac{\left(\frac{\pi \times 10^2}{4}\right)}{144} = 0.55\ ft^2$$

$$A_b = \frac{\left(\frac{\pi \times 7^2}{4}\right)}{144} = 0.24\ ft^2$$

$$V_c = \frac{1{,}000}{0.55} = 1818\ fpm$$

$$V_b = \frac{2{,}083}{0.24} = 2083\ fpm$$

Example

- Solution

$$p_{v,c} = \left(\frac{1818}{4005}\right)^2 = 0.21\ in\ w.c.$$

$$p_{v,b} = \left(\frac{2083}{4005}\right)^2 = 0.27\ in\ w.c.$$

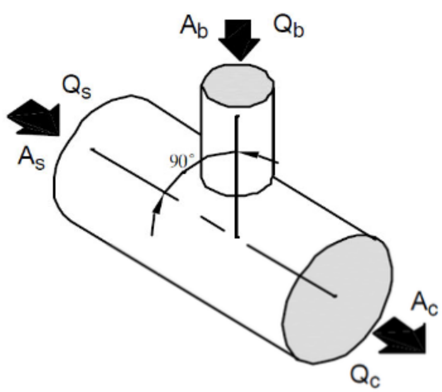
$$\frac{Q_b}{Q_c} = \frac{500}{1000} = 0.50$$

$$\frac{A_b}{A_c} = \frac{0.24}{0.5} = 0.44$$

Example

- Solution

B. CONVERGING TEE, 90°, ROUND



O_b/Q_c	Branch, Coefficient C (*See* Note 8) A_b/A_c 0.1	0.2	0.3	0.4	0.6	0.8	1.0
0.1	0.40	-0.37	-0.51	-0.46	-0.50	-0.51	-0.52
0.2	3.8	0.72	0.17	-0.02	-0.14	-0.18	-0.24
0.3	9.2	2.3	1.0	0.44	0.21	0.11	-0.08
0.4	16	4.3	2.1	0.94	0.54	0.40	0.32
0.5	26	6.8	3.2	1.1	0.66	0.49	0.42
0.6	37	9.7	4.7	1.6	0.92	0.69	0.57
0.7	43	13	6.3	2.1	1.2	0.88	0.72
0.8	65	17	7.9	2.7	1.5	1.1	0.86
0.9	82	21	9.7	3.4	1.8	1.2	0.99
1.0	101	26	12	4.0	2.1	1.4	1.1

Main, Coefficient C (*See* Note 8)										
O_b/Q_c	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
C	0.16	0.27	0.38	0.46	0.53	0.57	0.59	0.60	0.59	0.55

$C_b = 1.0$

$$\Delta p_{t,b-c} = 1 \times 0.21 = 0.21\ in\ w.c.$$

$$\Delta p_{t,b-c} = 053 \times 0.27 = 0.14\ in\ w.c.$$