VENTILATION SYSTEM DESIGN

Dr. Thammarak Srimarut

Ref.: Henry J. McDermott. ๒๐๐๑. *Handbook of Ventilation for Contaminant Control*. Ohio. American Conference of Governmental Industrial Hygienists (ACGIH).

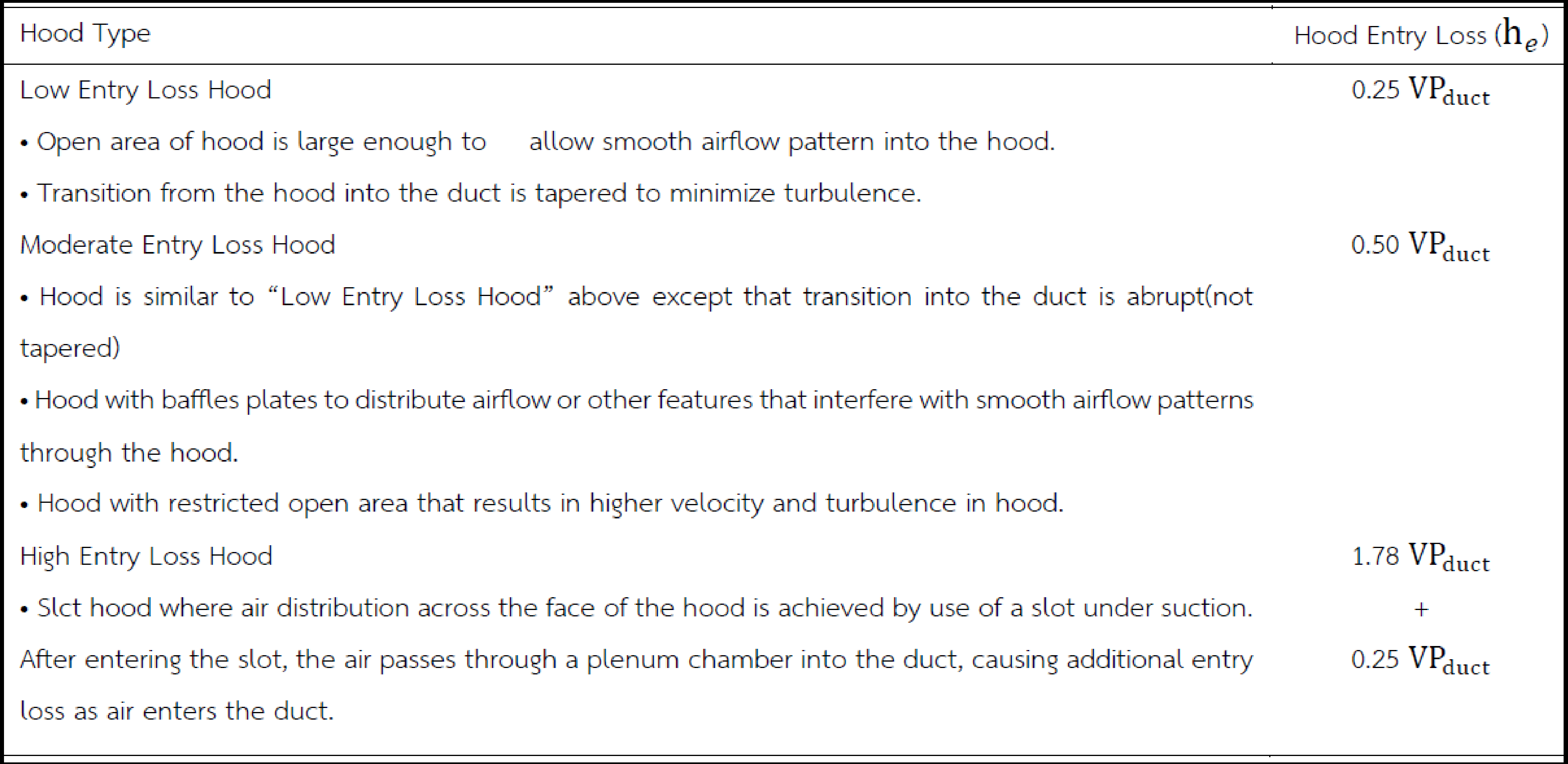
DESIGN OVERVIEW

The first step in system design is choosing the hood types and location, type of air cleaner (if any), and other parameters for the system. After the design parameters have been chosen, the design calculations determine the diameter for each duct segment, actual total airflow through the system, fan size (f3/min and Fan Static Pressure rating) and other information needed to build the system so it functions properly and is economical to install and operate. In order to size the ducts and fan, design data (such as hood entry loss coefficients and duct friction loss factors) are needed. It is also helpful to have some design aids such as a calculation worksheet and chart of the standard duct diameters that are generally available.

LOCAL EXHAUST SYSTEM COMPONENTS

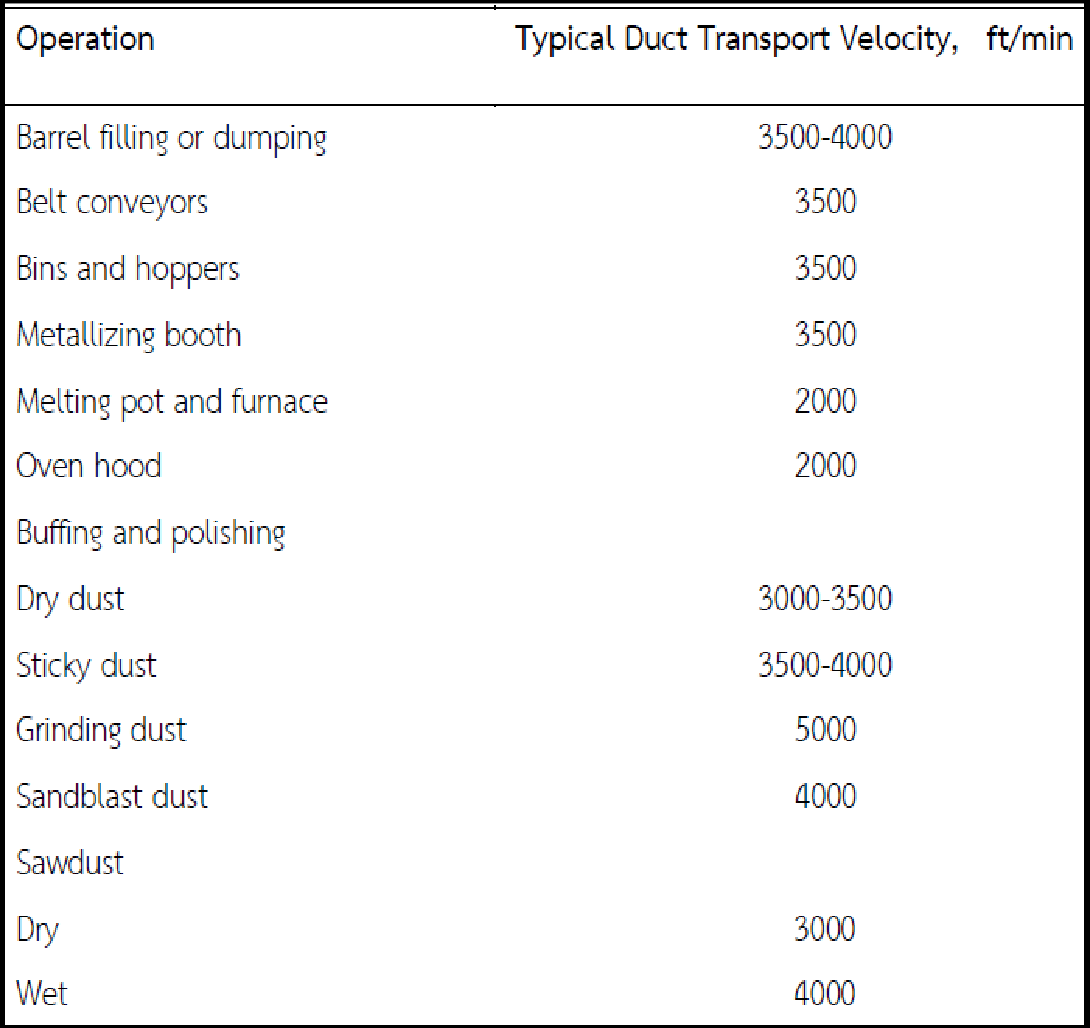
• Hoods	Capture velocity, Hood entry loss
• Ducts	Minimum duct velocity, Friction Loss (duct loss, elbow loss, branch entry loss, fittings loss)
• Air cleaner	Air cleaner loss
• Fan	Fan static pressure, Break horse power
• Exhaust stack	Duct loss

HOOD ENTRY LOSS FOR TYPICAL HOOD TYPES

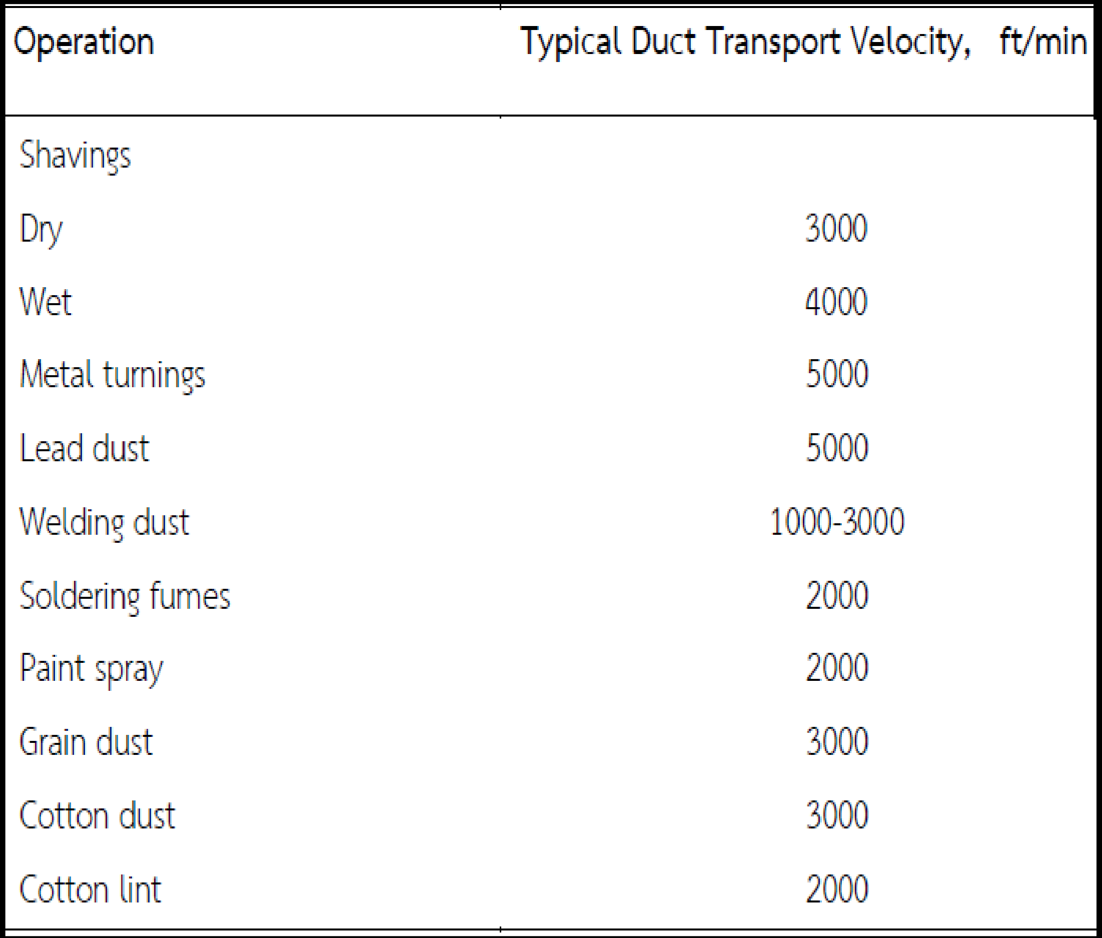


Hood Type	Hood Entry Loss (h_e)
Low Entry Loss Hood • Open area of hood is large enough to allow smooth airflow pattern into the hood. • Transition from the hood into the duct is tapered to minimize turbulence.	$0.25\ VP_{duct}$
Moderate Entry Loss Hood • Hood is similar to "Low Entry Loss Hood" above except that transition into the duct is abrupt(not tapered) • Hood with baffles plates to distribute airflow or other features that interfere with smooth airflow patterns through the hood. • Hood with restricted open area that results in higher velocity and turbulence in hood.	$0.50\ VP_{duct}$
High Entry Loss Hood • Slct hood where air distribution across the face of the hood is achieved by use of a slot under suction. After entering the slot, the air passes through a plenum chamber into the duct, causing additional entry loss as air enters the duct.	$1.78\ VP_{duct}$ + $0.25\ VP_{duct}$

TYPICAL MINIMUM DUCT TRANSPORT VELOCITIES



Operation	Typical Duct Transport Velocity, ft/min
Barrel filling or dumping	3500-4000
Belt conveyors	3500
Bins and hoppers	3500
Metallizing booth	3500
Melting pot and furnace	2000
Oven hood	2000
Buffing and polishing	
Dry dust	3000-3500
Sticky dust	3500-4000
Grinding dust	5000
Sandblast dust	4000
Sawdust	
Dry	3000
Wet	4000



Operation	Typical Duct Transport Velocity, ft/min
Shavings	
Dry	3000
Wet	4000
Metal turnings	5000
Lead dust	5000
Welding dust	1000-3000
Soldering fumes	2000
Paint spray	2000
Grain dust	3000
Cotton dust	3000
Cotton lint	2000

FRICTION LOSS FACTORS FOR GALVANIZED SHEET METAL DUCTS

	Friction Loss, Number of VP_d per foot				
Diameter, inches	2000 ft/min	3000 ft/min	4000 ft/min	5000 ft/min	6000 ft/min
1	0.4088	0.3959	0.3870	0.3802	0.3748
1.5	0.2489	0.2410	0.2356	0.2315	0.2282
2	0.1750	0.1695	0.1657	0.1628	0.1605
2.5	0.1332	0.1290	0.1261	0.1239	0.1221
3	0.1065	0.1032	0.1009	0.0991	0.0977
3.5	0.0882	0.0854	0.0835	0.0821	0.0809
4	0.0749	0.0726	0.0709	0.0697	0.0687
4.5	0.0649	0.0628	0.0614	0.0603	0.0595
5	0.0507	0.0552	0.0540	0.0530	0.0523
5.5	0.0507	0.0491	0.0480	0.0472	0.0465
6	0.0456	0.0442	0.0432	0.0424	0.0418
6.5	0.0417	0.0404	0.0395	0.0388	0.0382
7	0.0378	0.0366	0.0358	0.0351	0.0346
7.5	0.0350	0.0339	0.0331	0.0324	0.0320
8	0.0321	0.0311	0.0304	0.0298	0.0294
8.5	0.0300	0.0290	0.0284	0.0278	0.0274
9	0.0278	0.0265	0.0263	0.0258	0.0255
10	0.0244	0.0236	0.0231	0.0227	0.0224
11	0.0217	0.0210	0.0206	0.0202	0.0199

	Friction Loss, Number of VP_d per foot				
Diameter, inches	2000 ft/min	3000 ft/min	4000 ft/min	5000 ft/min	6000 ft/min
12	0.0195	0.0189	0.0185	0.0182	0.0179
13	0.0177	0.0171	0.0168	0.0165	0.0162
14	0.0162	0.0157	0.0153	0.0150	0.0148
15	0.0149	0.0144	0.0141	0.0138	0.0136
16	0.0137	0.0133	0.0130	0.0128	0.0126
17	0.0127	0.0123	0.0121	0.0119	0.0117
18	0.0119	0.0115	0.0113	0.0111	0.0109
19	0.0111	0.0108	0.0105	0.0103	0.0102
20	0.0104	0.0101	0.0099	0.0097	0.0096
22	0.0093	0.0090	0.0088	0.0086	0.0085
24	0.0084	0.0081	0.0079	0.0078	0.0077
26	0.0076	0.0073	0.0072	0.0070	0.0069
28	0.0069	0.0067	0.0066	0.0064	0.0063
30	0.0064	0.0062	0.0060	0.0059	0.0058
35	0.0053	0.0051	0.0050	0.0049	0.0048
40	0.0045	0.0043	0.0042	0.0042	0.0041
45	0.0039	0.0038	0.0037	0.0036	0.0036
50	0.0034	0.0033	0.0032	0.0032	0.0031
60	0.0027	0.0026	0.0026	0.0025	0.0025

Source: ACGIH Industrilal Ventilation Manual.

EXAMPLE FOR “DUCT LOSS”

- What is the friction loss in an 8-in. duct with 3500 ft/min duct velocity that is 35 ft long?

the friction loss factor must be estimated from the given information:

Dia., in.	3000 ft/min vel.	4000 ft/min vel.
8.0	0.0311 VP_d/ft	0.0304 VP_d/ft

The loss factor for 3500 ft/min is halfway between the two given values, or 0.0308 VP_d/ft.

The friction loss for a duct 35 ft long is: $35ft\times\frac{0.0308\ VP_d}{ft}=1.08\ VP_d$

EXAMPLE FOR “DUCT LOSS” (CONTINUED…)

To convert this to a loss expressed in ″inches of water,

$$VP = [\frac{V}{4005}]^2$$ Where: VP = velocity pressure, inches of H2O

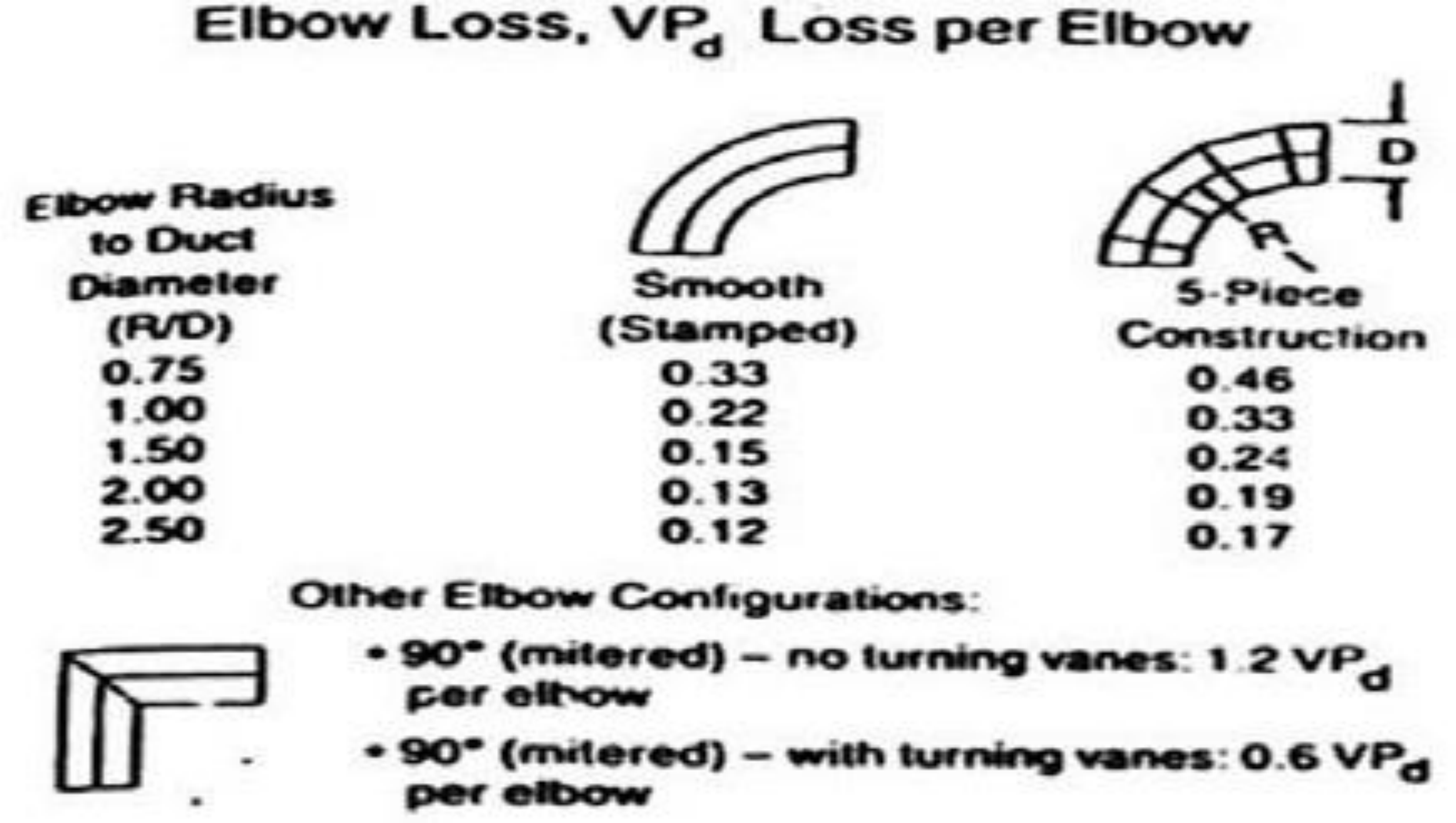
$$VP = [\frac{3500}{4005}]^2 = (0.87)^2 = 0.76 \text{ in.H2O}$$

$$\text{Pressure loss} = 1.08 \text{ VPd} \times \frac{0.76 \text{ in.H2O}}{\text{VPd}}$$

$$= 0.82 \text{ in.H2O}$$

ELBOW PRESSURE LOSS FOR ROUND DUCT ELBOWS

(SOURCE: ACGIH INDUSTRIAL VENTILATION MANUAL)



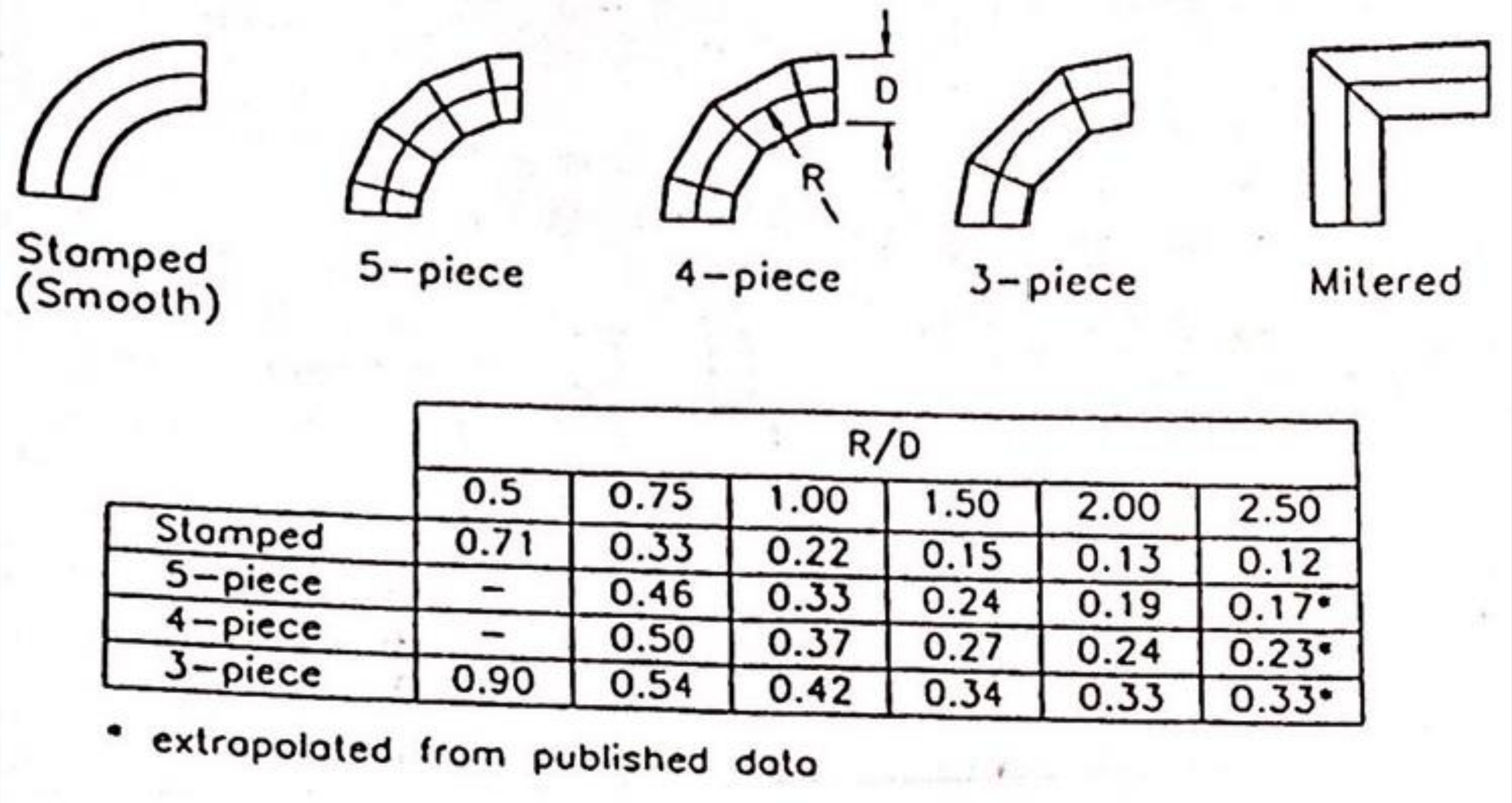
Elbow Loss, VP_d Loss per Elbow

Elbow Radius to Duct Diameter (R/D)	Smooth (Stamped)	5-Piece Construction
0.75	0.33	0.46
1.00	0.22	0.33
1.50	0.15	0.24
2.00	0.13	0.19
2.50	0.12	0.17

Other Elbow Configurations:

- 90° (mitered) – no turning vanes: 1.2 VP_d per elbow
- 90° (mitered) – with turning vanes: 0.6 VP_d per elbow

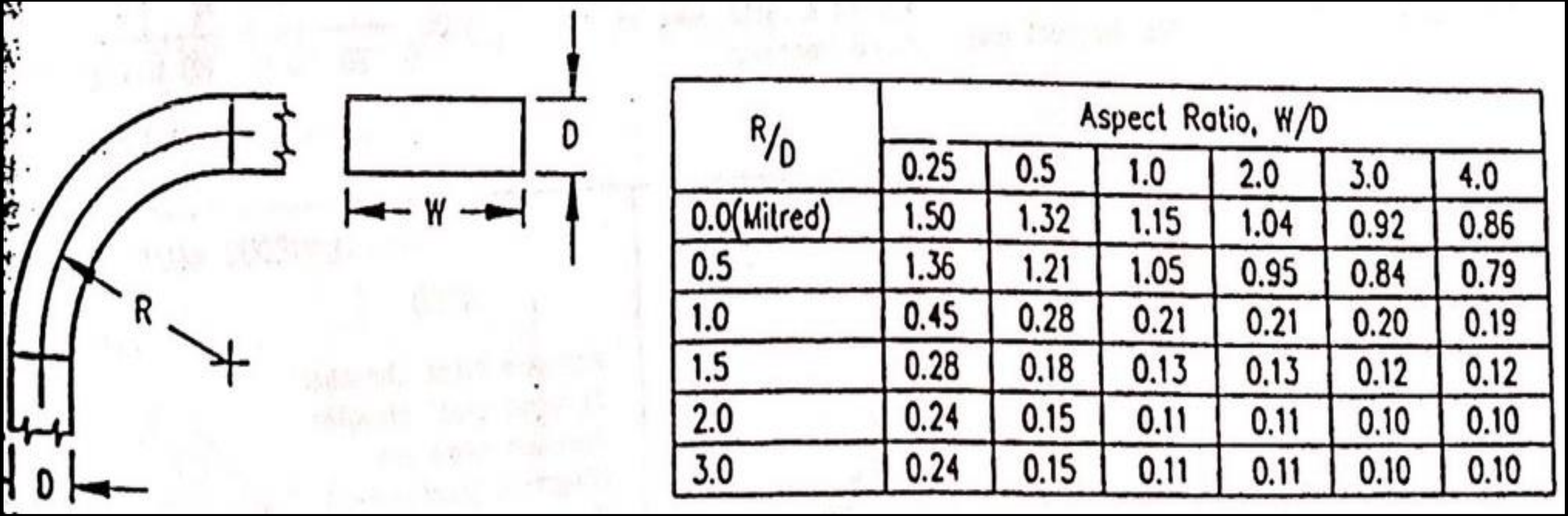
ROUND ELBOW LOSS COEFFICIENTS



	R/D					
	0.5	0.75	1.00	1.50	2.00	2.50
Stamped	0.71	0.33	0.22	0.15	0.13	0.12
5–piece	–	0.46	0.33	0.24	0.19	0.17*
4–piece	–	0.50	0.37	0.27	0.24	0.23*
3–piece	0.90	0.54	0.42	0.34	0.33	0.33*

* extrapolated from published data

SQUARE AND RECTANGULAR ELBOW LOSS COEFFICIENTS



R/D	Aspect Ratio, W/D					
	0.25	0.5	1.0	2.0	3.0	4.0
0.0(Mitred)	1.50	1.32	1.15	1.04	0.92	0.86
0.5	1.36	1.21	1.05	0.95	0.84	0.79
1.0	0.45	0.28	0.21	0.21	0.20	0.19
1.5	0.28	0.18	0.13	0.13	0.12	0.12
2.0	0.24	0.15	0.11	0.11	0.10	0.10
3.0	0.24	0.15	0.11	0.11	0.10	0.10

EXAMPLE FOR “ELBOW LOSS”

- The 8–in. duct described above has two 90 ° elbows and a 45 ° bend. If the elbows are smooth (stamped) and have a radius that is twice the duct diameter, what is the elbow turbulence loss?

The loss per elbow is 0.13 duct velocity pressure for a smooth elbow with R / D = 2.0 Counting the 45 ° bend as 0.5 elbow:

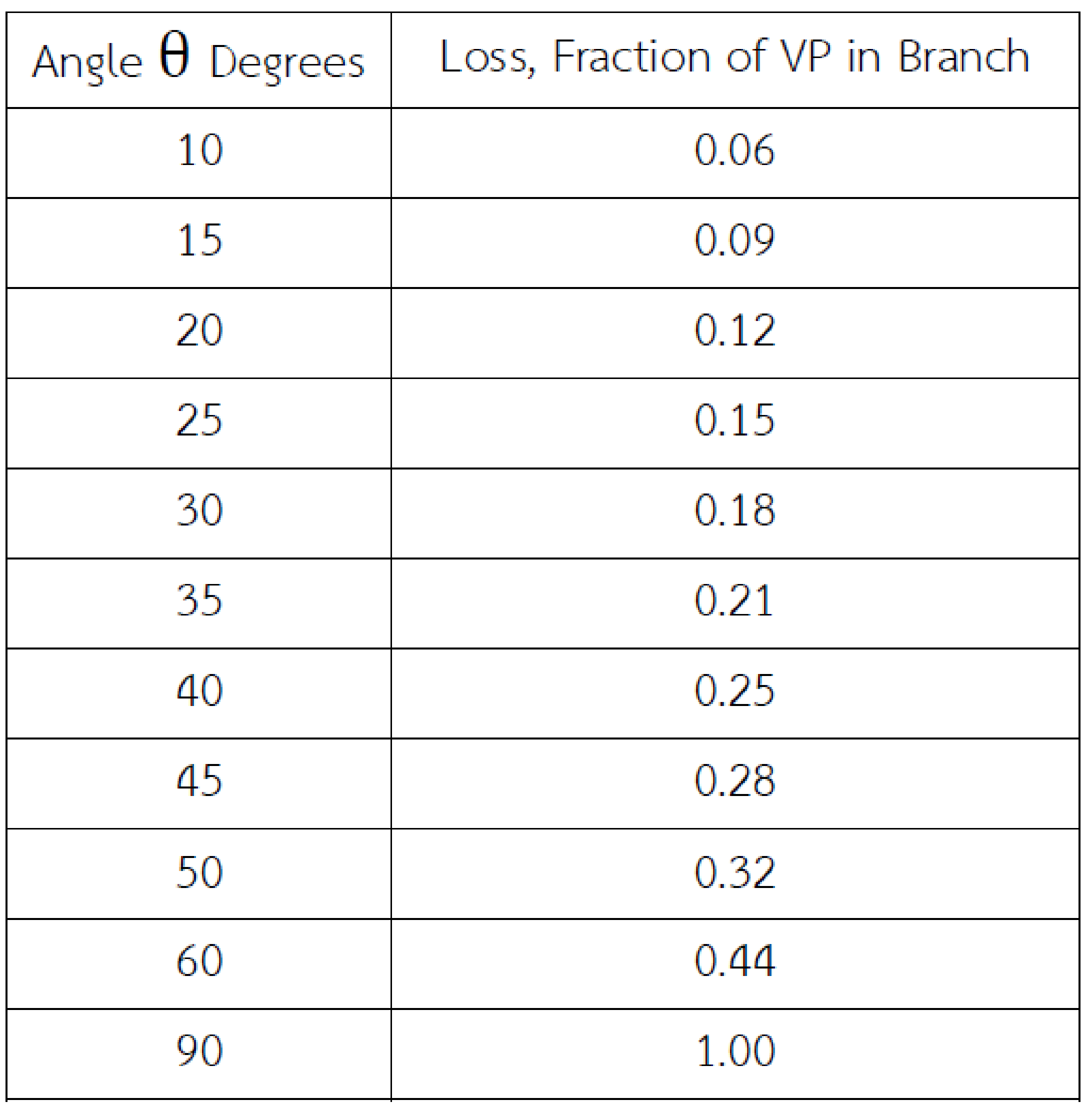
$$2.5 \text{ elbows} \times 0.13 \frac{\mathrm{VP_d}}{\mathrm{elbow}} = 0.33 \ \mathrm{VP_d}$$

EXAMPLE FOR “ELBOW LOSS” (CONTINUED…)

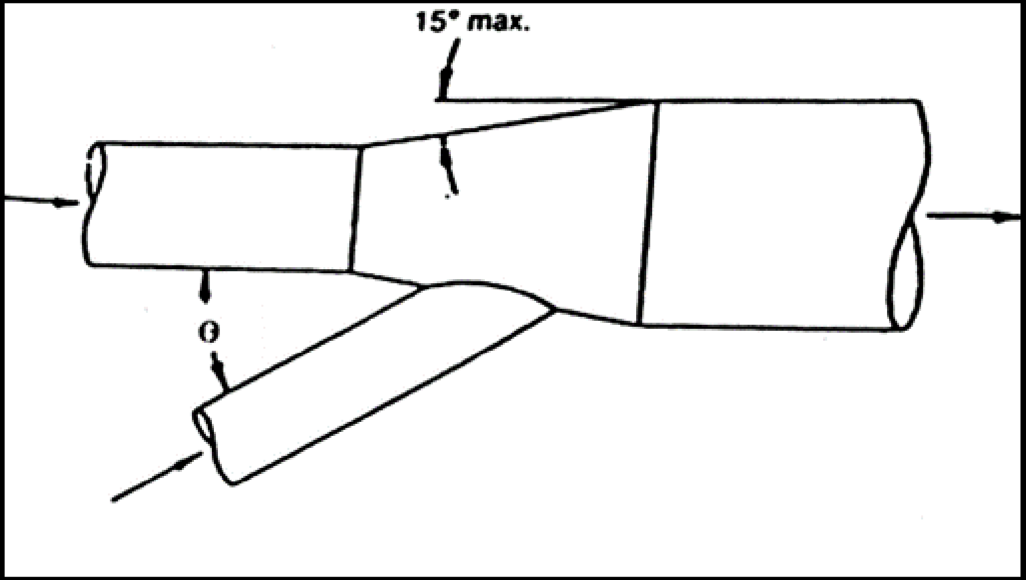
From the earlier calculation, the velocity pressure in the duct is 0.76 in. of water, so the actual pressure loss is:

$$0.33\ \mathrm{VP_d} \times \frac{0.76\ \mathrm{in.H_2O}}{\mathrm{vp_d}} = 0.25\ \text{in.}\ \mathrm{H_2O}$$

BRANCH DUCT ENTRY PRESSURE LOSS



Angle θ Degrees	Loss, Fraction of VP in Branch
10	0.06
15	0.09
20	0.12
25	0.15
30	0.18
35	0.21
40	0.25
45	0.28
50	0.32
60	0.44
90	1.00



(Source: ACGIH Industrial Ventilation Manual)

EXAMPLE FOR “BRANCH ENTRY LOSS”

- The 8–in. duct with VP of 0.76 in. H, O in the previous examples is a branch duct that enters a main duct at a 30 ° angle. What is the branch entry loss?

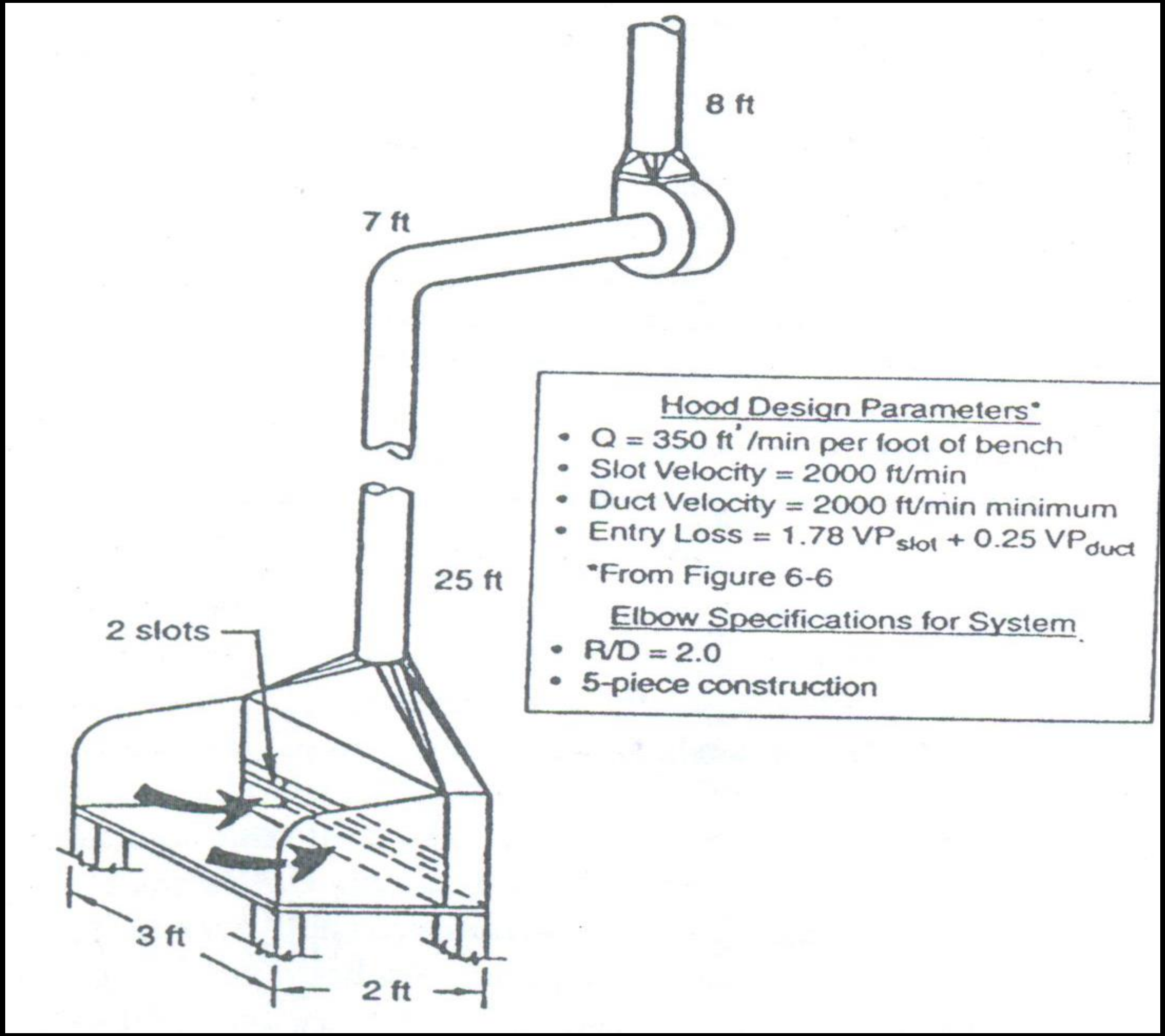
A pressure loss of 0.18 velocity pressure occurs in the 8–in. branch duct. The pressure loss is:

$$0.18\ \mathrm{VP_d} \times \frac{\mathbf{0.76\ in.H_2O}}{\mathbf{vp_d}} = 0.14\ \text{in.}\ \mathrm{H_2O}$$

SINGLE–HOOD SYSTEM

Sample Design 1: Welding Bench System

Design the welding bench system shown in this figure to operate at standard conditions. Hood design parameters from the ACGIH Industrial Ventilation Manual and summarized in this figure. Use 3000 ft/min as the minimum duct velocity to prevent settling.



Hood Design Parameters*

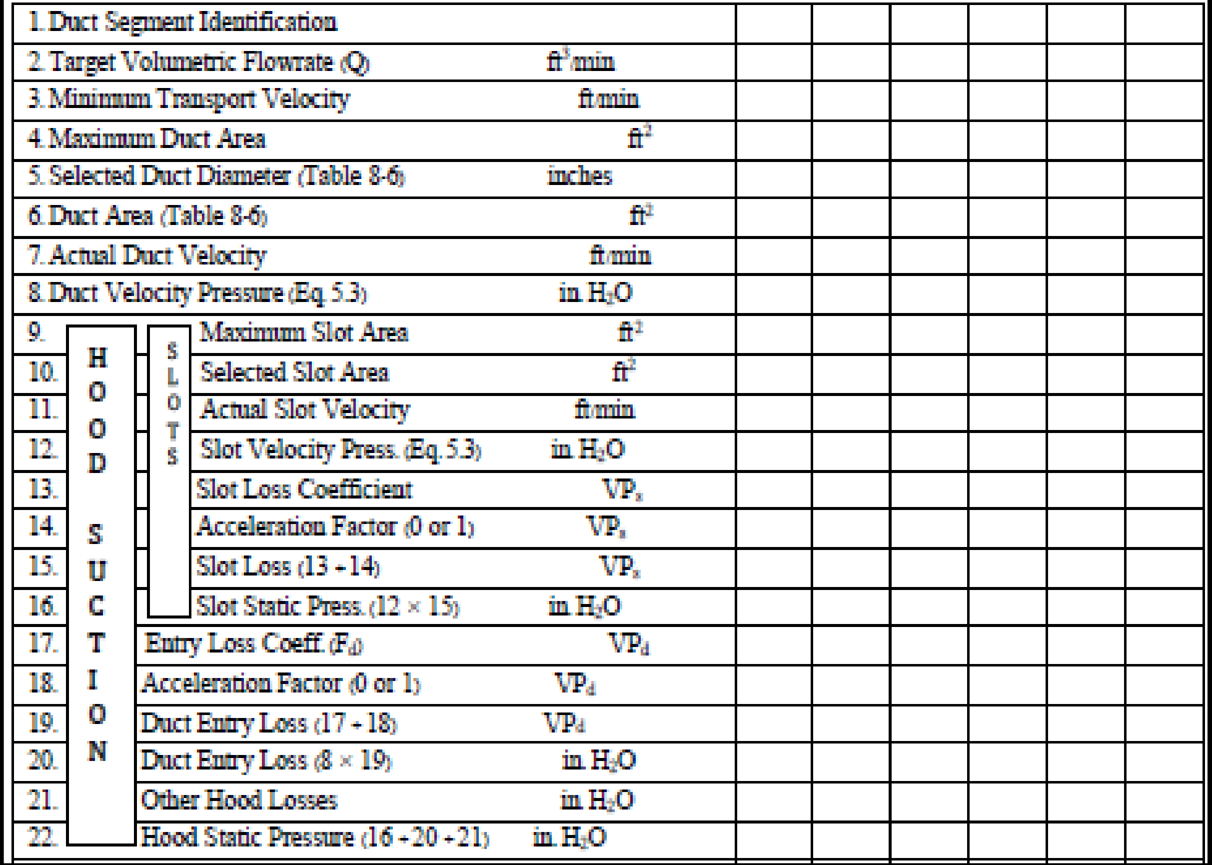
- Q = 350 ft^3/min per foot of bench
- Slot Velocity = 2000 ft/min
- Duct Velocity = 2000 ft/min minimum
- Entry Loss = $1.78\ VP_{slot} + 0.25\ VP_{duct}$

*From Figure 6-6

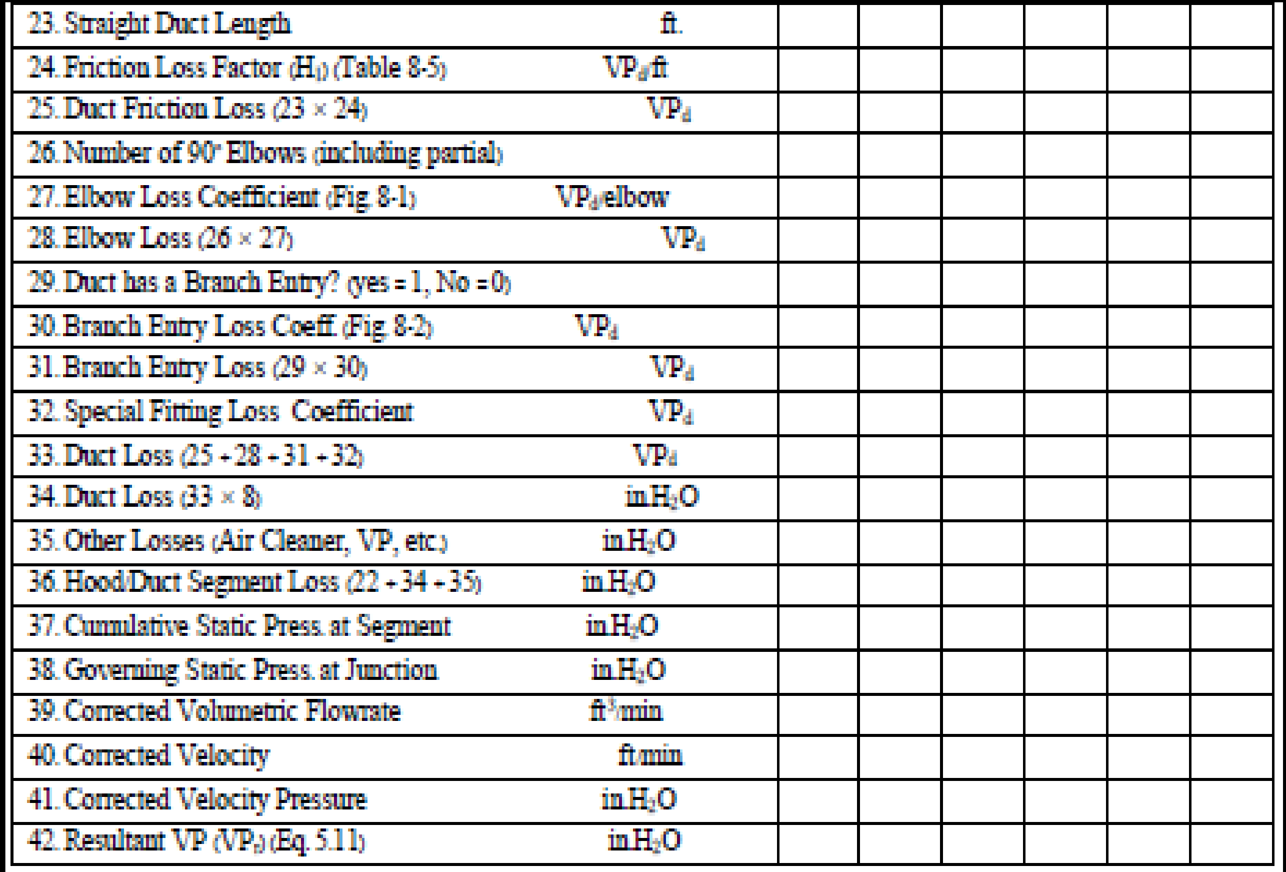
Elbow Specifications for System

- R/D = 2.0
- 5-piece construction

CALCULATION WORKSHEET FOR SYSTEM DESIGN

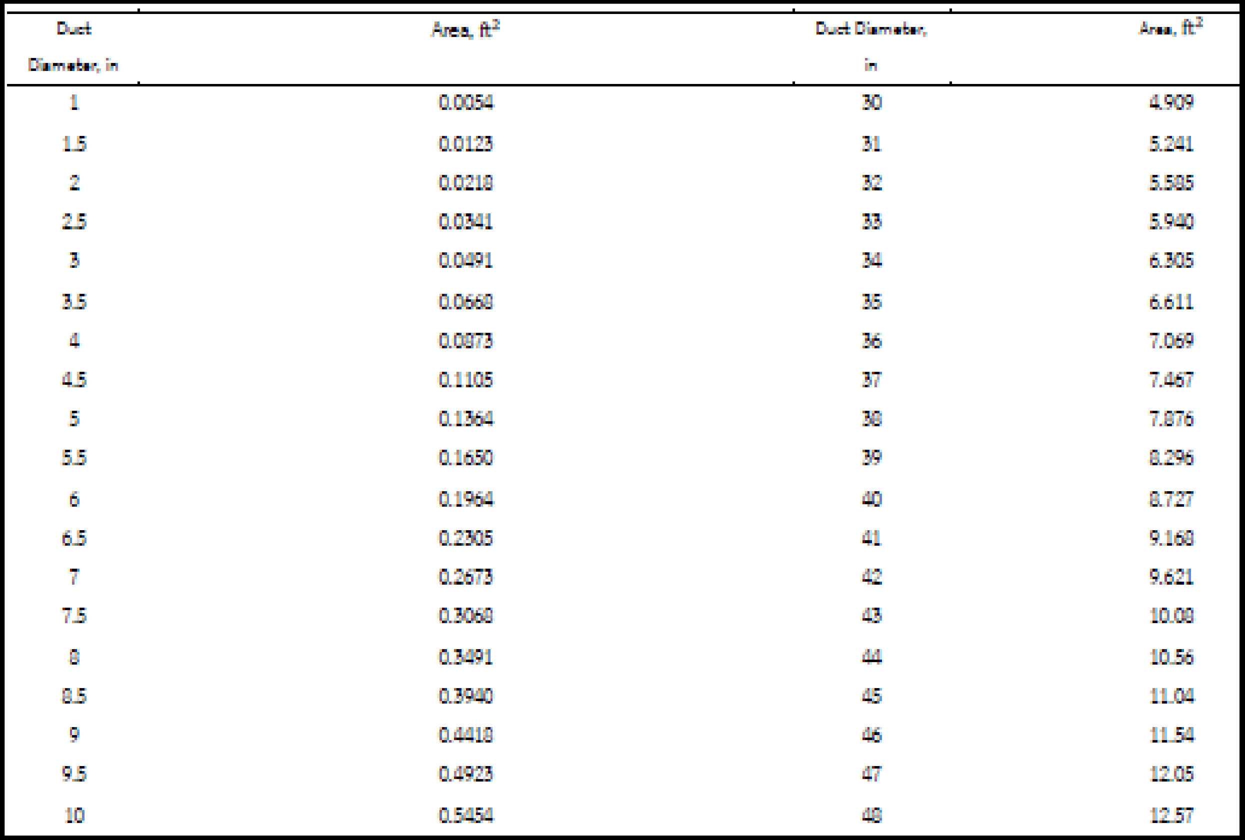


1.			Duct Segment Identification							
2.			Target Volumetric Flowrate (Q)	ft^3/min						
3.			Minimum Transport Velocity	ft/min						
4.			Maximum Duct Area	ft^2						
5.			Selected Duct Diameter (Table 8-6)	inches						
6.			Duct Area (Table 8-6)	ft^2						
7.			Actual Duct Velocity	ft/min						
8.			Duct Velocity Pressure (Eq. 5.3)	in. H_2O						
9.	HOOD SUCTION	SLOTS	Maximum Slot Area	ft^2						
10.			Selected Slot Area	ft^2						
11.			Actual Slot Velocity	ft/min						
12.			Slot Velocity Press. (Eq. 5.3)	in. H_2O						
13.			Slot Loss Coefficient	VP_s						
14.			Acceleration Factor (0 or 1)	VP_s						
15.			Slot Loss (13 + 14)	VP_s						
16.			Slot Static Press. (12 × 15)	in. H_2O						
17.			Entry Loss Coeff. (F_d)	VP_d						
18.			Acceleration Factor (0 or 1)	VP_d						
19.			Duct Entry Loss (17 + 18)	VP_d						
20.			Duct Entry Loss (8 × 19)	in. H_2O						
21.			Other Hood Losses	in. H_2O						
22.			Hood Static Pressure (16 + 20 + 21)	in. H_2O						

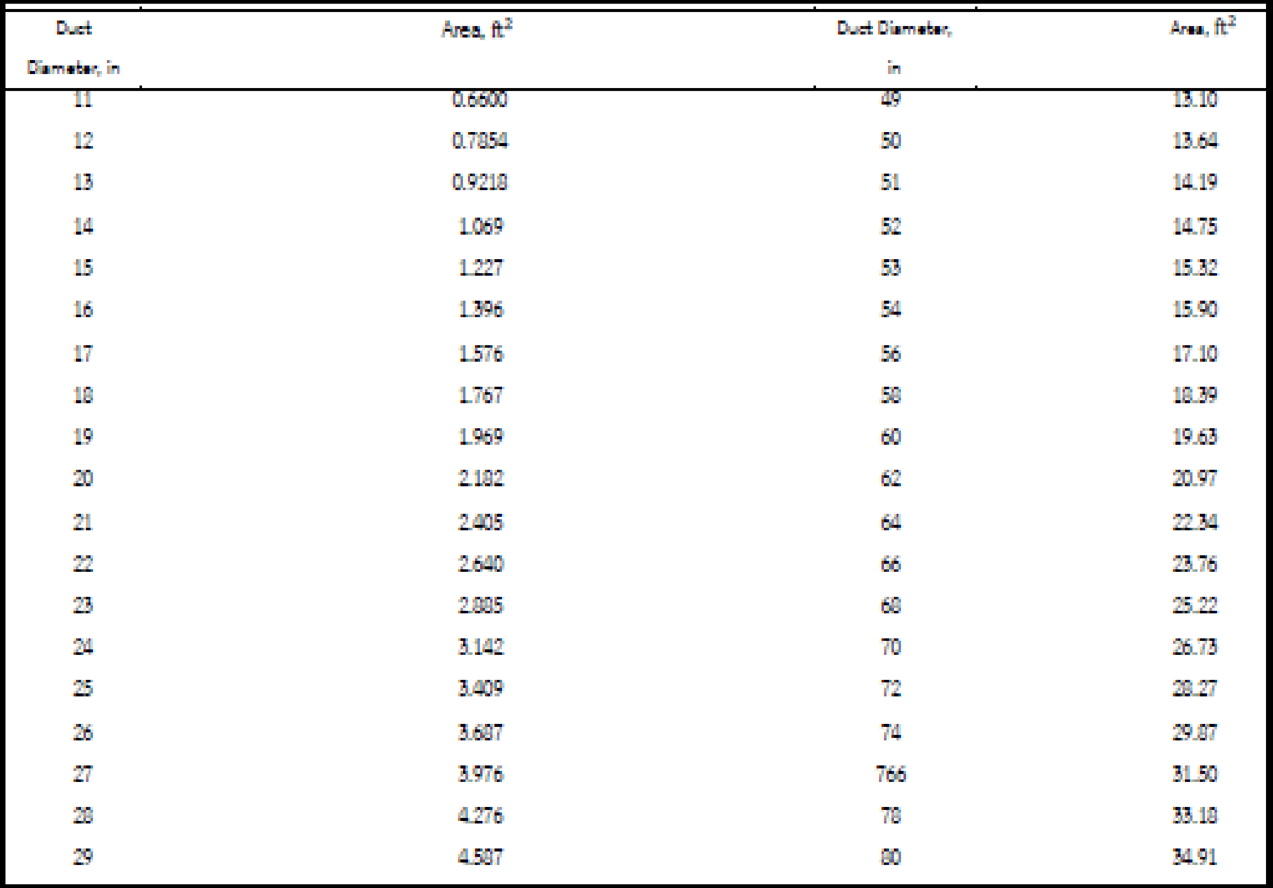


23. Straight Duct Length	ft.						
24. Friction Loss Factor (H_f) (Table 8-5)	VP_d/ft						
25. Duct Friction Loss (23 × 24)	VP_d						
26. Number of 90° Elbows (including partial)							
27. Elbow Loss Coefficient (Fig. 8-1)	VP_d/elbow						
28. Elbow Loss (26 × 27)	VP_d						
29. Duct has a Branch Entry? (yes = 1, No = 0)							
30. Branch Entry Loss Coeff. (Fig. 8-2)	VP_d						
31. Branch Entry Loss (29 × 30)	VP_d						
32. Special Fitting Loss Coefficient	VP_d						
33. Duct Loss (25 + 28 + 31 + 32)	VP_d						
34. Duct Loss (33 × 8)	in. H_2O						
35. Other Losses (Air Cleaner, VP, etc.)	in. H_2O						
36. Hood/Duct Segment Loss (22 + 34 + 35)	in. H_2O						
37. Cumulative Static Press. at Segment	in. H_2O						
38. Governing Static Press. at Junction	in. H_2O						
39. Corrected Volumetric Flowrate	ft^3/min						
40. Corrected Velocity	ft/min						
41. Corrected Velocity Pressure	in. H_2O						
42. Resultant VP (VP_r) (Eq. 5.11)	in. H_2O						

DUCT AREA FOR STANDARD DIAMETER DUCTS



Duct Diameter, in	Area, ft^2	Duct Diameter, in	Area, ft^2
1	0.0054	30	4.909
1.5	0.0123	31	5.241
2	0.0218	32	5.585
2.5	0.0341	33	5.940
3	0.0491	34	6.305
3.5	0.0668	35	6.611
4	0.0873	36	7.069
4.5	0.1105	37	7.467
5	0.1364	38	7.876
5.5	0.1650	39	8.296
6	0.1964	40	8.727
6.5	0.2305	41	9.168
7	0.2673	42	9.621
7.5	0.3068	43	10.08
8	0.3491	44	10.56
8.5	0.3940	45	11.04
9	0.4418	46	11.54
9.5	0.4923	47	12.05
10	0.5454	48	12.57



Duct Diameter, in	Area, ft^2	Duct Diameter, in	Area, ft^2
11	0.6600	49	13.10
12	0.7854	50	13.64
13	0.9218	51	14.19
14	1.069	52	14.75
15	1.227	53	15.32
16	1.396	54	15.90
17	1.576	56	17.10
18	1.767	58	18.39
19	1.969	60	19.63
20	2.182	62	20.97
21	2.405	64	22.34
22	2.640	66	23.76
23	2.885	68	25.22
24	3.142	70	26.73
25	3.409	72	28.27
26	3.687	74	29.87
27	3.976	766	31.50
28	4.276	78	33.18
29	4.587	80	34.91

Source: ACGIH Industrilal Ventilation Manual.

SOLUTION:

1. Identify the duct before the fan as Duct and the exhaust stack as Stack.
2. Target Volumetric Flowrate (Q) = 1050 $\mathrm{ft}^3/\mathrm{min}$ calculated from

$$Q = \frac{350\ \mathrm{ft}^3/\mathrm{min}}{\mathrm{ft\ length}} \times 3\ \mathrm{ft\ long} = 1050\ \mathrm{ft}^3/\mathrm{min}$$

3. Minimum Transport Velocity = 3000 ft/min
4. Maximum Duct Area:

$$A = \frac{Q}{V} = \frac{1050\ \mathrm{ft}^3/\mathrm{min}}{3000\ \mathrm{ft/min}} = 0.35\ \mathrm{ft}^2$$

5. Selected Duct Diameter = 8.0 in.

SOLUTION:

6. Duct Area = 0.3491 ft^2

7. Actual Duct Velocity:

$$\mathrm{V} = \frac{\mathrm{Q}}{\mathrm{A}} = \frac{1050\ \mathrm{ft}^3/\mathrm{min}}{0.3491\ \ \mathrm{ft}^2} = 3008\ \mathrm{ft/min}$$

8. Duct Velocity Pressure:

$$\mathrm{VP} = \left(\frac{\mathrm{V}}{4005}\right)^2 = \left(\frac{3008}{4005}\right)^2 = 0.56\ \mathrm{in.\,H_2O}$$

9. Maximum Slot Area (to give the 2000 ft/min slot velocity:

$$\mathrm{A} = \frac{\mathrm{Q}}{\mathrm{V_{slot}}} = \frac{1050\ \mathrm{ft}^3/\mathrm{min}}{2000\ \mathrm{ft/min}} = 0.525\ \mathrm{ft}^2$$

SOLUTION:

10. Select the maximum slot area that will give 2000 ft/min. which is 0.525 f^2

11. Actual Slot Velocity:

$$V_{slot} = \frac{Q}{A_{slot}} = \frac{1050\ ft^3/min}{0.525\ ft^2} = 2000\ ft/min$$

12. Slot Velocity Pressure:

$$VP_{slot} = \left(\frac{V}{4005}\right)^2 = \left(\frac{2000}{4005}\right)^2 = 0.25\ in.H_2O$$

13. Slot Loss Coefficient = 1.78 VP_{slot}

14. Acceleration Loss Factor = 0 since the duct velocity is greater than the slot velocity.

SOLUTION:

15. Slot Loss = 1.78 $\mathrm{VP_{slot}}$
16. Slot Static Pressure

$$1.78_{\mathrm{slot}} \times \frac{0.25\ \mathrm{in.H_2O}}{\mathrm{VP_{slot}}} = 0.45\ \mathrm{in.\,H_2O}$$

17. Entry Loss Coefficient = 0.25 $\mathrm{VP_d}$
18. Acceleration Factor = 1.0 to account for the acceleration loss for this hood. (since the duct velocity is greater than slot)
19. Duct Entry Loss = 1.0 $\mathrm{VP_d}$ + 0.25 $\mathrm{VP_d}$ = 1,25 $\mathrm{VP_d}$

SOLUTION:

20. Duct Entry Loss

$$1.78_{\mathrm{VP_d}} \times \frac{0.56\ \mathrm{in.H_2O}}{\mathrm{VP_d}} = 0.70\ \mathrm{in.\,H_2O}$$

21. Other Hood Losses: no other losses

22. Hood Static Pressure = Slot Static Pressure + Duct Entry Loss

$$\mathrm{SP}\ _{\mathrm{h}} = 0.45\ \text{in.}\ \mathrm{H_2O} + 0.70\ \text{in.}\ \mathrm{H_2O} = 1.15\ \text{in.}\ \mathrm{H_2O}$$

23. Straight Duct Length = 32 ft.

24. Friction Loss Factor = 0.0311 $\mathrm{VP_d}$/ft for an 8–in. duct with 3000 ft/min duct velocity.

SOLUTION:

25. Duct Friction Loss = 32 ft × $\frac{0.0311\mathrm{VP_d}}{\mathrm{ft}} = 0.995\mathrm{VP_d} = 1.00\ \mathrm{VP_d}$

26. Number of 90 ° Elbows = 1

27. Elbows Loss Coefficient = 0.19 $\mathrm{VP_d}$ per elbow for a 5-piece elbow with R/D = 2.0

28. Elbow Loss = 1 Elbow × $\frac{0.19\mathrm{VP_d}}{\mathrm{Elbow}} = 0.19\mathrm{VP_d}$

29. This entry is zero because this duct is not a branch duct entering a main duct.

30–32. Do not apply to this duct segment.

SOLUTION:

33. Duct Loss = 1.00 $\mathrm{VP_d}$ + 0.19 $\mathrm{VP_d}$ = 1.19 $\mathrm{VP_d}$

34. Duct Loss:

$$1.19_{\mathrm{VP_d}} \times \frac{0.56\ \mathrm{in.H_2O}}{\mathrm{VP_d}} = 0.67\ \mathrm{in.\,H_2O}$$

35. Other Losses: none

36. Hood/Duct Segment Loss = 1.15 in. $\mathrm{H_2O}$ + 0.67 in.$\mathrm{H_2O}$ = 1.82 in. $\mathrm{H_2O}$

37. Cumulative Static Pressure = 1.82 in. $\mathrm{H_2O}$

38–42. Do not apply to this single hood system.

SOLUTION:

Stack

1–8. Same as in the Duct column since the Q and duct velocity criteria are the same.

9–22. Are blank because there is no hood in this segment.

23. Straight Duct Length = 8 ft.

24. Same as the Duct column because diameter and $\mathrm{V_d}$ are the same.

25. Duct Friction Loss = 8 ft $\times \frac{0.0311\mathrm{VP_d}}{\mathrm{ft}} = 0.25\mathrm{VP_d}$

SOLUTION:

26–28. Zero or blank because there are no elbows in this segment:

29. This entry is zero because this duct is not a branch duct entering a main duct.

30–32. Do not apply to this segment.

33. Duct Loss = 0.25 VP

34. Duct Loss = *0.14* in. $\mathrm{H_2O}$

35. no other losses

36. Hood/Duct Segment Loss = 0.14 in $\mathrm{H_2O}$

SOLUTION:

37. Cumulative Static Pressure = 0.14 in. H_2O

38–42. Do not apply to this system

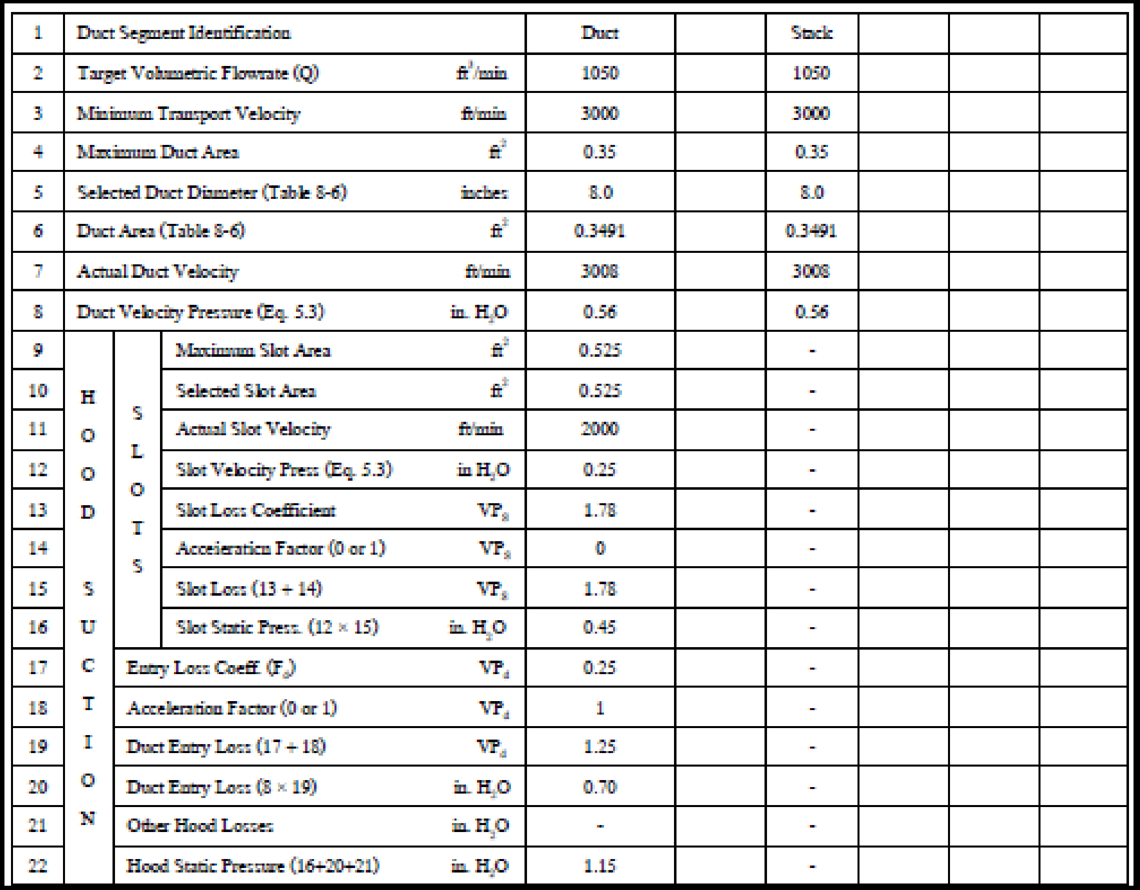
With this information on the Duct and Stack, the Fan Static Pressure can be calculated :

$$\text{FSP} = |SP_{inlet}| + |SP_{outlet}| - VP_{inlet}$$

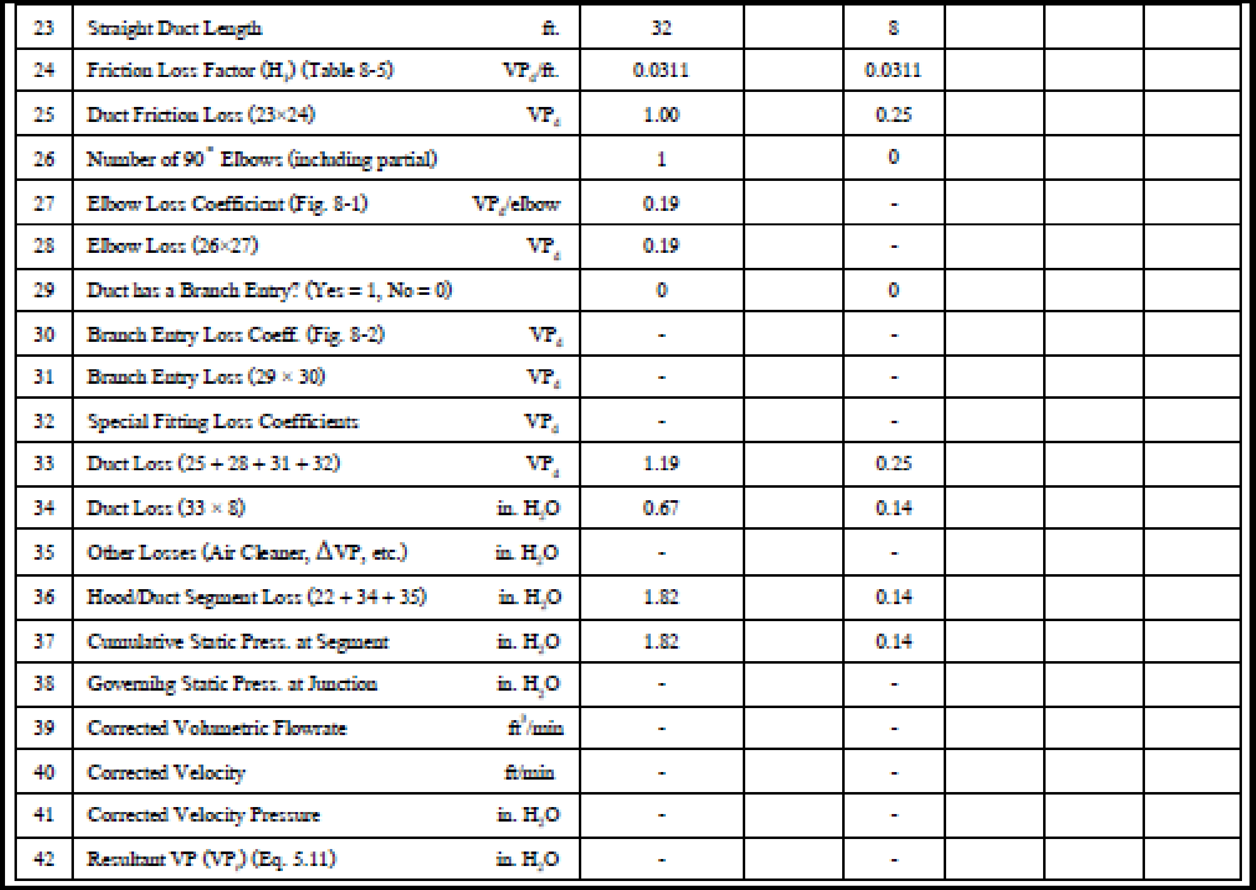
$$\text{FSP} = |1.82|{+}|0.14|{-}0.56$$

$$\text{FSP} = 1.40 \text{ in. } H_2O$$

CALCULATION WORKSHEET FOR SYSTEM DESIGN



1	Duct Segment Identification				Duct		Stack			
2	Target Volumetric Flowrate (Q)			ft^3/min	1050		1050			
3	Minimum Transport Velocity			ft/min	3000		3000			
4	Maximum Duct Area			ft^2	0.35		0.35			
5	Selected Duct Diameter (Table 8-6)			inches	8.0		8.0			
6	Duct Area (Table 8-6)			ft^2	0.3491		0.3491			
7	Actual Duct Velocity			ft/min	3008		3008			
8	Duct Velocity Pressure (Eq. 5.3)			in. H_2O	0.56		0.56			
9	HOOD SUCTION	SLOTS	Maximum Slot Area	ft^2	0.525		-			
10			Selected Slot Area	ft^2	0.525		-			
11			Actual Slot Velocity	ft/min	2000		-			
12			Slot Velocity Press (Eq. 5.3)	in H_2O	0.25		-			
13			Slot Loss Coefficient	VP_s	1.78		-			
14			Acceieration Factor (0 or 1)	VP_s	0		-			
15			Slot Loss (13 + 14)	VP_s	1.78		-			
16			Slot Static Press. (12 × 15)	in. H_2O	0.45		-			
17		Entry Loss Coeff. (F_d)		VP_d	0.25		-			
18		Acceleration Factor (0 or 1)		VP_d	1		-			
19		Duct Entry Loss (17 + 18)		VP_d	1.25		-			
20		Duct Entry Loss (8 × 19)		in. H_2O	0.70		-			
21		Other Hood Losses		in. H_2O	-		-			
22		Hood Static Pressure (16+20+21)		in. H_2O	1.15		-			

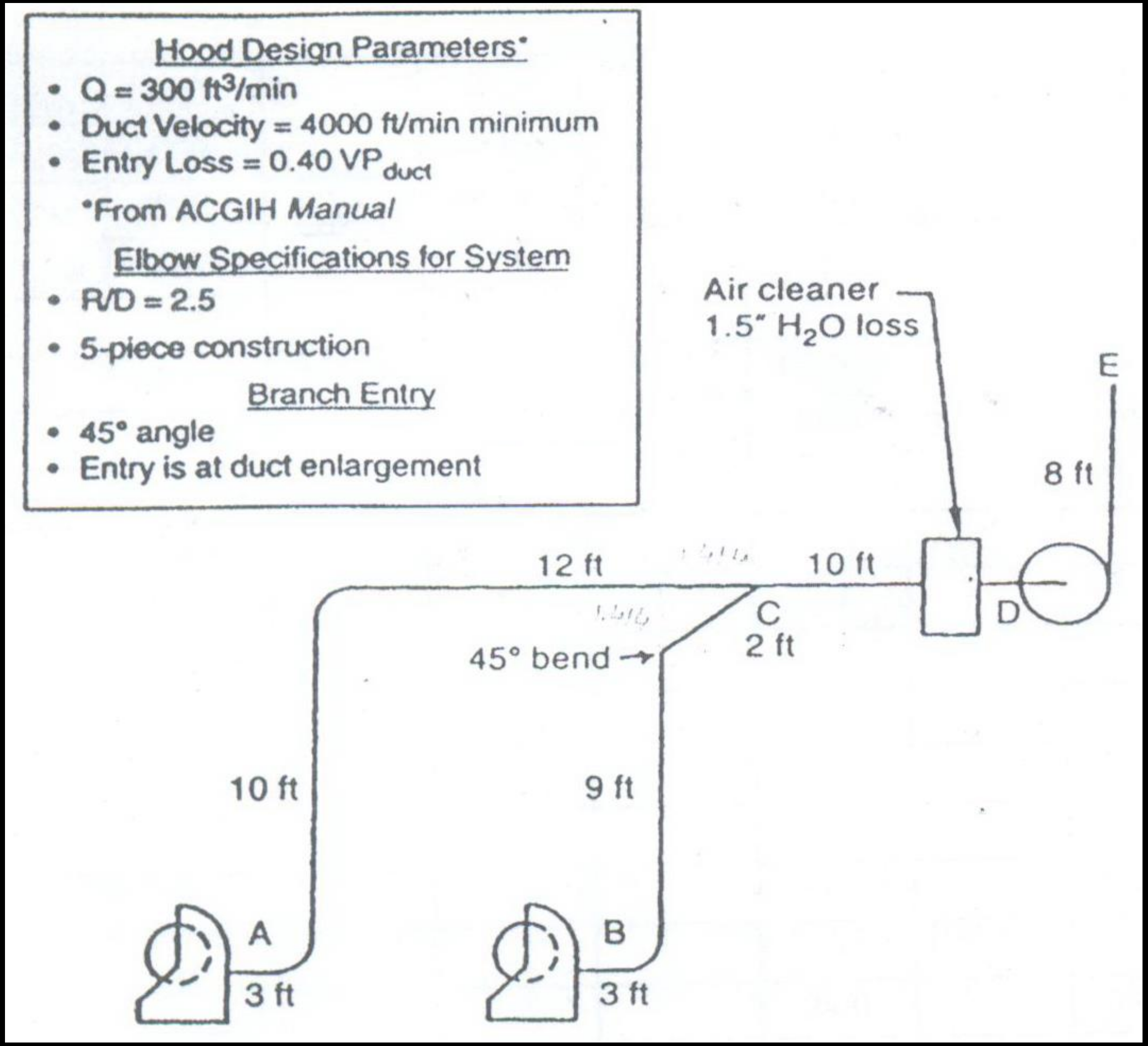


23	Straight Duct Length	ft.	32		8			
24	Friction Loss Factor (H_f) (Table 8-5)	VP_d/ft.	0.0311		0.0311			
25	Duct Friction Loss (23×24)	VP_d	1.00		0.25			
26	Number of 90° Elbows (including partial)		1		0			
27	Elbow Loss Coefficient (Fig. 8-1)	VP_d/elbow	0.19		-			
28	Elbow Loss (26×27)	VP_d	0.19		-			
29	Duct has a Branch Entry? (Yes = 1, No = 0)		0		0			
30	Branch Entry Loss Coeff. (Fig. 8-2)	VP_d	-		-			
31	Branch Entry Loss (29 × 30)	VP_d	-		-			
32	Special Fitting Loss Coefficients	VP_d	-		-			
33	Duct Loss (25 + 28 + 31 + 32)	VP_d	1.19		0.25			
34	Duct Loss (33 × 8)	in. H_2O	0.67		0.14			
35	Other Losses (Air Cleaner, ΔVP, etc.)	in. H_2O	-		-			
36	Hood/Duct Segment Loss (22 + 34 + 35)	in. H_2O	1.82		0.14			
37	Cumulative Static Press. at Segment	in. H_2O	1.82		0.14			
38	Governihg Static Press. at Junction	in. H_2O	-		-			
39	Corrected Volumetric Flowrate	ft^3/min	-		-			
40	Corrected Velocity	ft/min	-		-			
41	Corrected Velocity Pressure	in. H_2O	-		-			
42	Resultant VP (VP_r) (Eq. 5.11)	in. H_2O	-		-			

MULTIPLE-HOOD SYSTEMS

Sample Design 2: pedestal Grinder System–Blast Gate Design

Design the system with two Pedestal Grinders shown in Figure that also shows design parameters such as duct length, elbow details and branch entry angle. The two grinders are identical;, the relevant hood design information from the ACGIH Industrial Ventilation Manual. Use 4000 f/min as the minimum duct velocity.



Hood Design Parameters*

- $Q = 300$ ft^3/min
- Duct Velocity = 4000 ft/min minimum
- Entry Loss = 0.40 VP_{duct}

*From ACGIH *Manual*

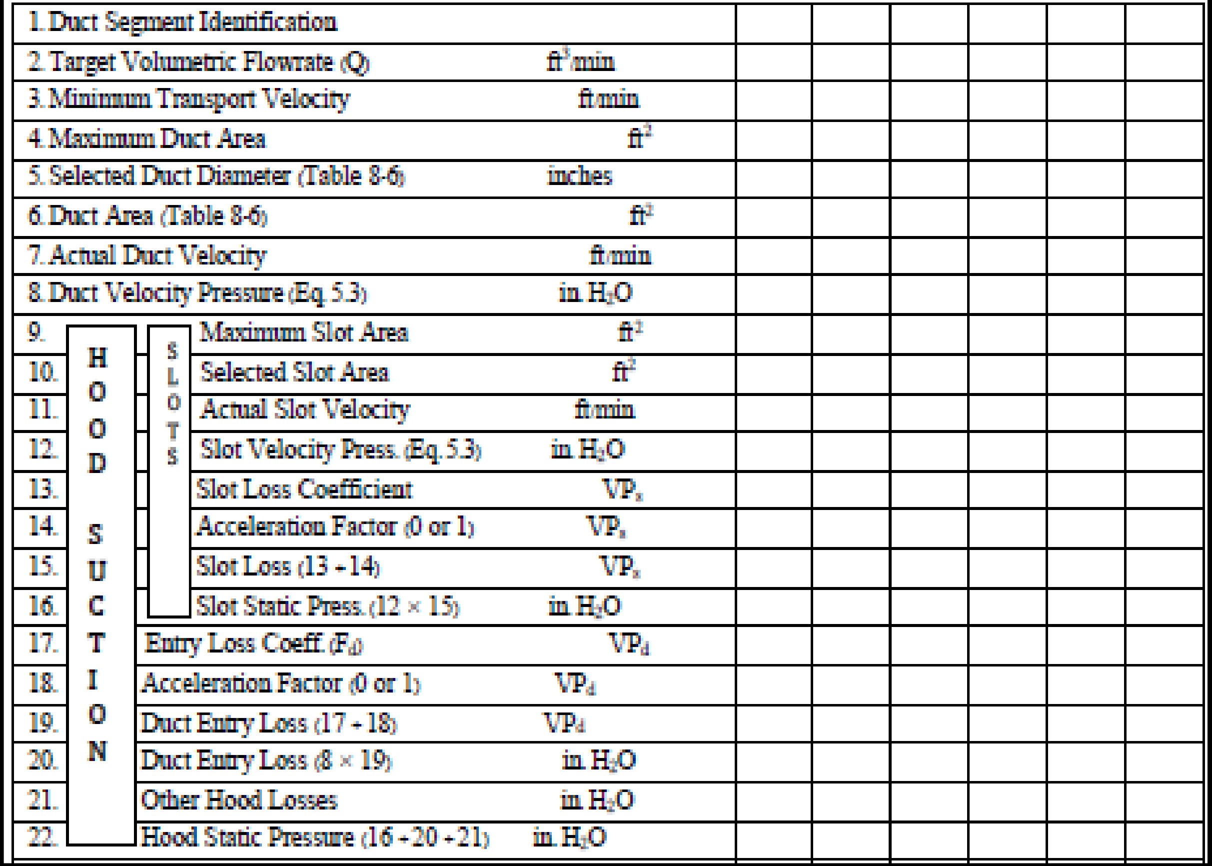
Elbow Specifications for System

- R/D = 2.5
- 5-piece construction

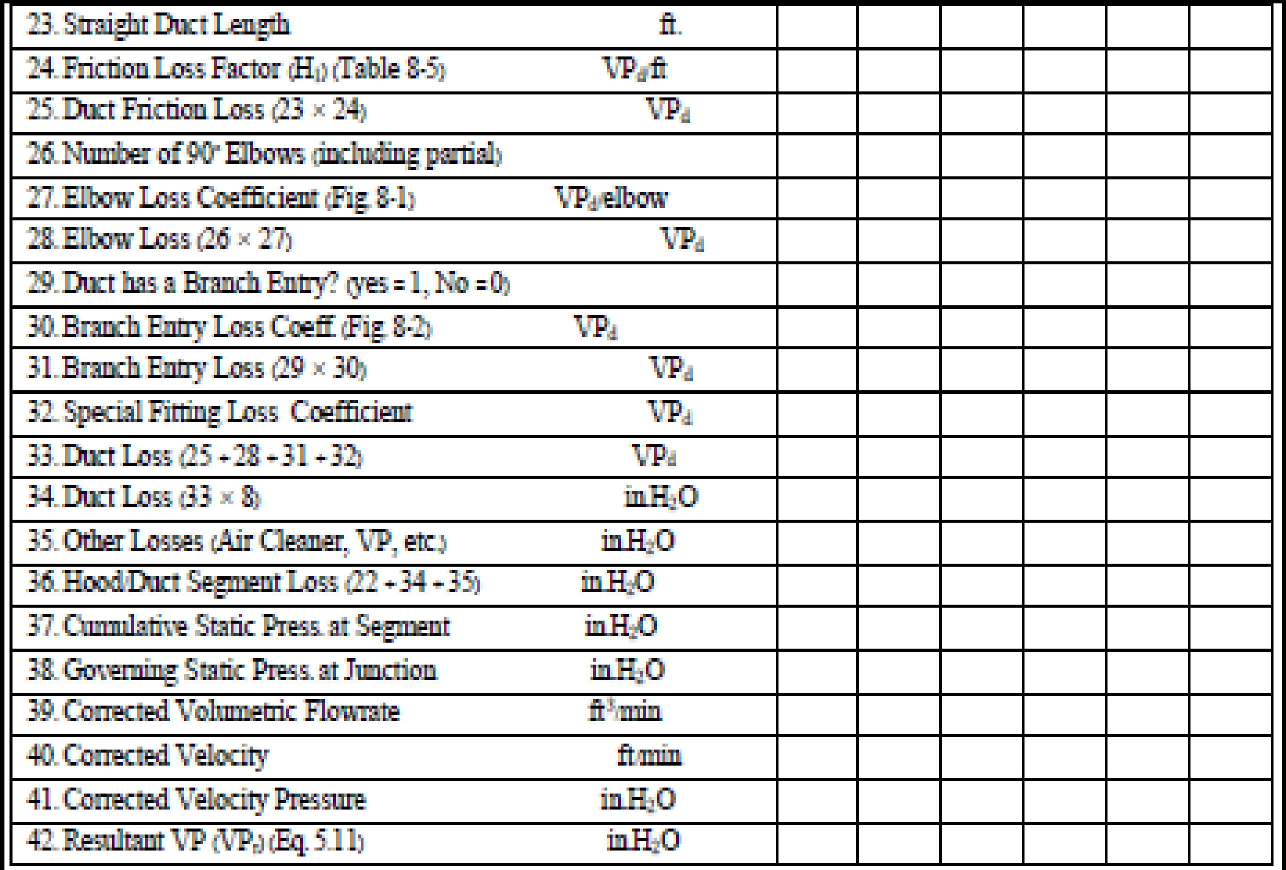
Branch Entry

- 45° angle
- Entry is at duct enlargement

CALCULATION WORKSHEET FOR SYSTEM DESIGN

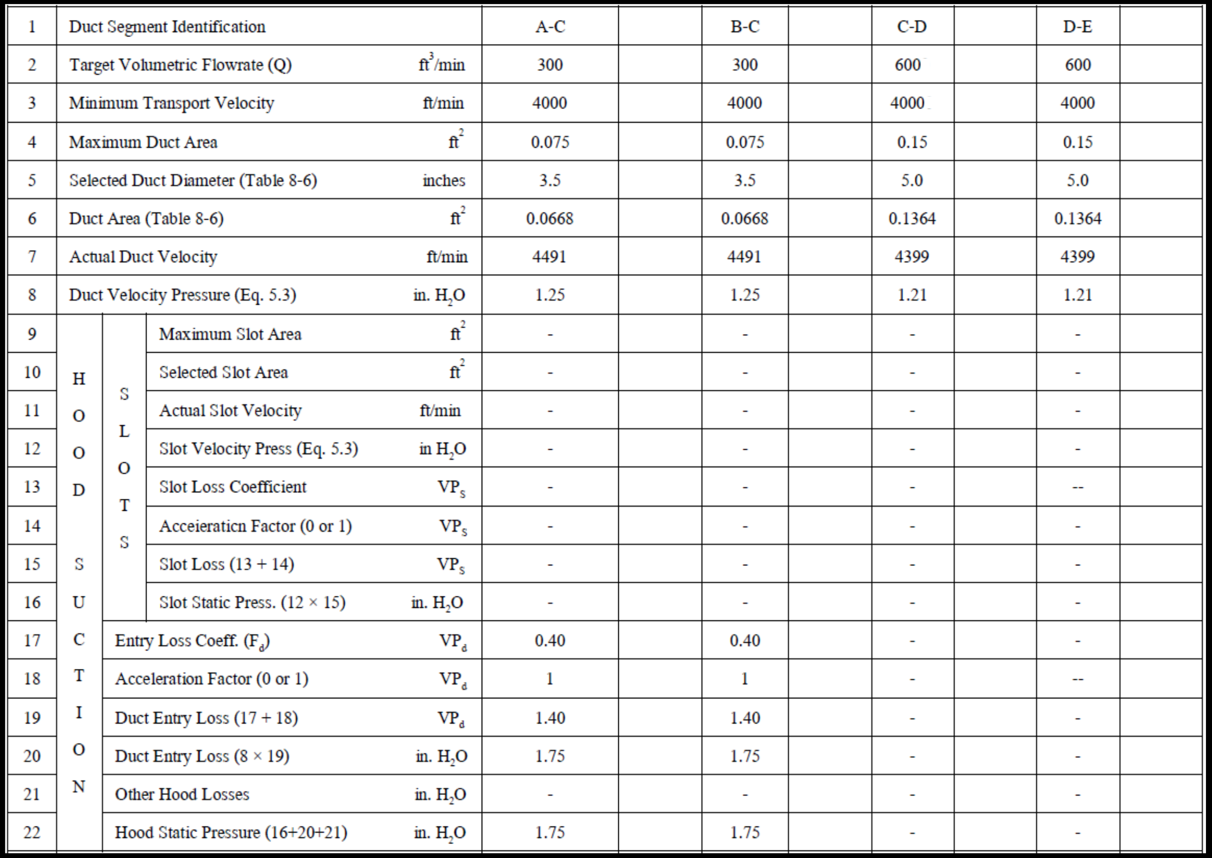


1. Duct Segment Identification										
2. Target Volumetric Flowrate (Q)				ft^3/min						
3. Minimum Transport Velocity				ft/min						
4. Maximum Duct Area				ft^2						
5. Selected Duct Diameter (Table 8-6)				inches						
6. Duct Area (Table 8-6)				ft^2						
7. Actual Duct Velocity				ft/min						
8. Duct Velocity Pressure (Eq. 5.3)				in. H_2O						
9.	HOOD SUCTION	SLOTS	Maximum Slot Area	ft^2						
10.			Selected Slot Area	ft^2						
11.			Actual Slot Velocity	ft/min						
12.			Slot Velocity Press. (Eq. 5.3)	in. H_2O						
13.			Slot Loss Coefficient	VP_s						
14.			Acceleration Factor (0 or 1)	VP_s						
15.			Slot Loss (13 + 14)	VP_s						
16.			Slot Static Press. (12 × 15)	in. H_2O						
17.		Entry Loss Coeff. (F_d)		VP_d						
18.		Acceleration Factor (0 or 1)		VP_d						
19.		Duct Entry Loss (17 + 18)		VP_d						
20.		Duct Entry Loss (8 × 19)		in. H_2O						
21.		Other Hood Losses		in. H_2O						
22.		Hood Static Pressure (16 + 20 + 21)		in. H_2O						

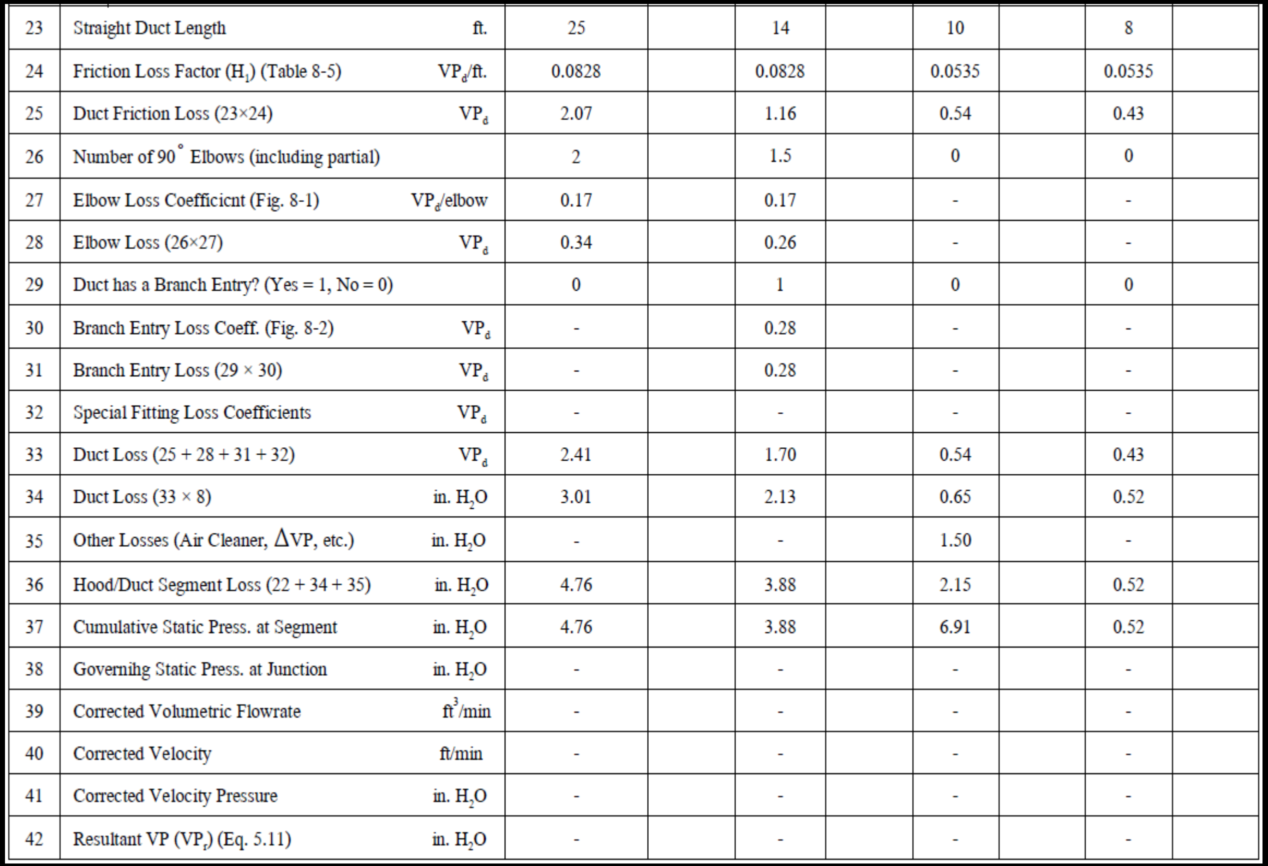


23. Straight Duct Length	ft.						
24. Friction Loss Factor (H_f) (Table 8-5)	VP_d/ft						
25. Duct Friction Loss (23 × 24)	VP_d						
26. Number of 90° Elbows (including partial)							
27. Elbow Loss Coefficient (Fig. 8-1)	VP_d/elbow						
28. Elbow Loss (26 × 27)	VP_d						
29. Duct has a Branch Entry? (yes = 1, No = 0)							
30. Branch Entry Loss Coeff. (Fig. 8-2)	VP_d						
31. Branch Entry Loss (29 × 30)	VP_d						
32. Special Fitting Loss Coefficient	VP_d						
33. Duct Loss (25 + 28 + 31 + 32)	VP_d						
34. Duct Loss (33 × 8)	in. H_2O						
35. Other Losses (Air Cleaner, VP, etc.)	in. H_2O						
36. Hood/Duct Segment Loss (22 + 34 + 35)	in. H_2O						
37. Cumulative Static Press. at Segment	in. H_2O						
38. Governing Static Press. at Junction	in. H_2O						
39. Corrected Volumetric Flowrate	ft^3/min						
40. Corrected Velocity	ft/min						
41. Corrected Velocity Pressure	in. H_2O						
42. Resultant VP (VP_r) (Eq. 5.11)	in. H_2O						

CALCULATION WORKSHEET FOR SYSTEM DESIGN



1			Duct Segment Identification		A-C		B-C		C-D		D-E	
2			Target Volumetric Flowrate (Q)	ft^3/min	300		300		600		600	
3			Minimum Transport Velocity	ft/min	4000		4000		4000		4000	
4			Maximum Duct Area	ft^2	0.075		0.075		0.15		0.15	
5			Selected Duct Diameter (Table 8-6)	inches	3.5		3.5		5.0		5.0	
6			Duct Area (Table 8-6)	ft^2	0.0668		0.0668		0.1364		0.1364	
7			Actual Duct Velocity	ft/min	4491		4491		4399		4399	
8			Duct Velocity Pressure (Eq. 5.3)	in. H_2O	1.25		1.25		1.21		1.21	
9	HOOD SUCTION	SLOTS	Maximum Slot Area	ft^2	-		-		-		-	
10			Selected Slot Area	ft^2	-		-		-		-	
11			Actual Slot Velocity	ft/min	-		-		-		-	
12			Slot Velocity Press (Eq. 5.3)	in H_2O	-		-		-		-	
13			Slot Loss Coefficient	VP_s	-		-		-		--	
14			Acceleration Factor (0 or 1)	VP_s	-		-		-		-	
15			Slot Loss (13 + 14)	VP_s	-		-		-		-	
16			Slot Static Press. (12 × 15)	in. H_2O	-		-		-		-	
17			Entry Loss Coeff. (F_d)	VP_d	0.40		0.40		-		-	
18			Acceleration Factor (0 or 1)	VP_d	1		1		-		--	
19			Duct Entry Loss (17 + 18)	VP_d	1.40		1.40		-		-	
20			Duct Entry Loss (8 × 19)	in. H_2O	1.75		1.75		-		-	
21			Other Hood Losses	in. H_2O	-		-		-		-	
22			Hood Static Pressure (16+20+21)	in. H_2O	1.75		1.75		-		-	



23	Straight Duct Length	ft.	25		14		10		8	
24	Friction Loss Factor (H_l) (Table 8-5)	VP_d/ft.	0.0828		0.0828		0.0535		0.0535	
25	Duct Friction Loss (23×24)	VP_d	2.07		1.16		0.54		0.43	
26	Number of 90° Elbows (including partial)		2		1.5		0		0	
27	Elbow Loss Coefficient (Fig. 8-1)	VP_d/elbow	0.17		0.17		-		-	
28	Elbow Loss (26×27)	VP_d	0.34		0.26		-		-	
29	Duct has a Branch Entry? (Yes = 1, No = 0)		0		1		0		0	
30	Branch Entry Loss Coeff. (Fig. 8-2)	VP_d	-		0.28		-		-	
31	Branch Entry Loss (29 × 30)	VP_d	-		0.28		-		-	
32	Special Fitting Loss Coefficients	VP_d	-		-		-		-	
33	Duct Loss (25 + 28 + 31 + 32)	VP_d	2.41		1.70		0.54		0.43	
34	Duct Loss (33 × 8)	in. H_2O	3.01		2.13		0.65		0.52	
35	Other Losses (Air Cleaner, ΔVP, etc.)	in. H_2O	-		-		1.50		-	
36	Hood/Duct Segment Loss (22 + 34 + 35)	in. H_2O	4.76		3.88		2.15		0.52	
37	Cumulative Static Press. at Segment	in. H_2O	4.76		3.88		6.91		0.52	
38	Governing Static Press. at Junction	in. H_2O	-		-		-		-	
39	Corrected Volumetric Flowrate	ft^3/min	-		-		-		-	
40	Corrected Velocity	ft/min	-		-		-		-	
41	Corrected Velocity Pressure	in. H_2O	-		-		-		-	
42	Resultant VP (VP_r) (Eq. 5.11)	in. H_2O	-		-		-		-	

FAN STATIC PRESSURE

FSP = |SPinlet|+|SPoutlet|−VPinlet

For this system: |SPinlet| = 6.91 in. of H2O (the Cumulative Static Pressure in C–D)

and |SPoutlet| = 0.52 in. of H2 O (the Cumulative Static Pressure in D–E)

so FSP = |16.91|+|10.520|−1.21

FSP = 6.22 in. H2O

For this Pedestal Grinder system to work properly with a Blast Gate design, a fan drawing 600 ft/min at 6.22 in. H2O Fan Static Pressure is required.