

VENTILATION SYSTEM DESIGN

Dr. Thammarak Srimarut

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 (cfm 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) |
|--|---|
| <p>Low Entry Loss Hood</p> <ul style="list-style-type: none"> • 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. | $0.25 VP_{duct}$ |
| <p>Moderate Entry Loss Hood</p> <ul style="list-style-type: none"> • 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. | $0.50 VP_{duct}$ |
| <p>High Entry Loss Hood</p> <ul style="list-style-type: none"> • Slot hood where air distribution across the face of the hood is achieved by use of a slot under suction. <p>After entering the slot, the air passes through a plenum chamber into the duct, causing additional entry loss as air enters the duct.</p> | $1.78 VP_{duct}$ + $0.25 VP_{duct}$ |

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 |

FRICION LOSS FACTORS FOR GALVANIZED SHEET METAL DUCTS

| Diameter, inches | Friction Loss, Number of VP _d per foot | | | | |
|------------------|---|-------------|-------------|-------------|-------------|
| | 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 |

| Diameter, inches | Friction Loss, Number of VP _d per foot | | | | |
|------------------|---|-------------|-------------|-------------|-------------|
| | 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 |

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:

$$\begin{array}{ccc} \frac{\text{Dia., in.}}{8.0} & \frac{3000 \text{ ft/min vel.}}{0.0311 \text{ VP}_d/\text{ft}} & \frac{4000 \text{ ft/min vel.}}{0.0304 \text{ VP}_d/\text{ft}} \end{array}$$

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

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

EXAMPLE FOR "DUCT LOSS" (CONTINUED...)

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

$$VP = \left[\frac{V}{4005} \right]^2$$

$$VP = \left[\frac{3500}{4005} \right]^2$$

Where: VP = velocity pressure, inches of H₂O

$$= (0.87)^2 = 0.76 \text{ in.H}_2\text{O}$$

$$\begin{aligned} \text{Pressure loss} &= 1.08 \text{ VP}_d \times \frac{0.76 \text{ in.H}_2\text{O}}{\text{VP}_d} \\ &= 0.82 \text{ in.H}_2\text{O} \end{aligned}$$

ELBOW PRESSURE LOSS FOR ROUND DUCT ELBOWS

(SOURCE: ACGIH INDUSTRIAL VENTILATION MANUAL)

Elbow Loss, VP_d Loss per Elbow

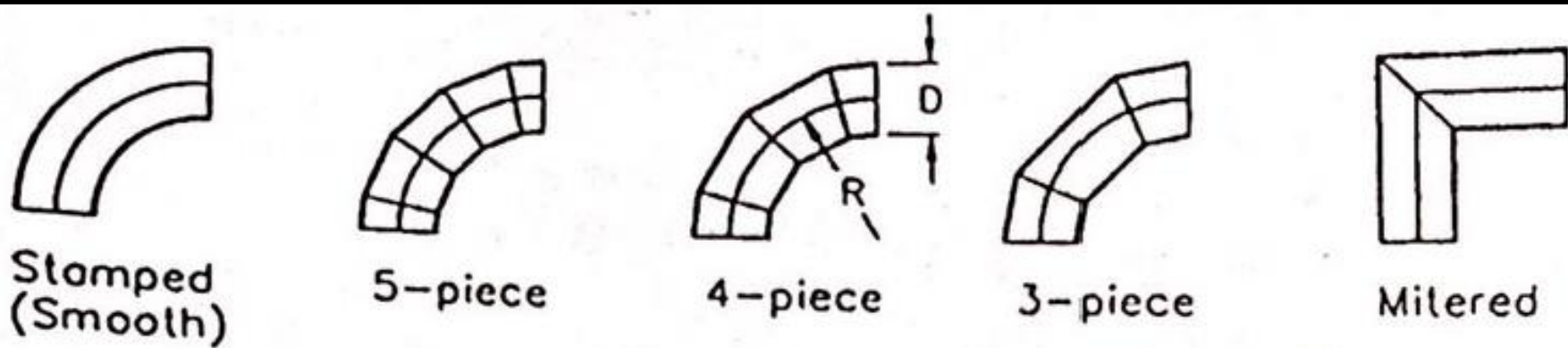
| Elbow Radius to Duct Diameter (R/D) | Smooth (Stamped) | 5-Piece Construction |
|--|---------------------|-------------------------|
| 0.75 | 0.33 | 0.46 |
| 1.00 | 0.22 | 0.33 |
| 1.50 | 0.15 | 0.24 |
| 2.00 | 0.13 | 0.19 |
| 2.50 | 0.12 | 0.17 |

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

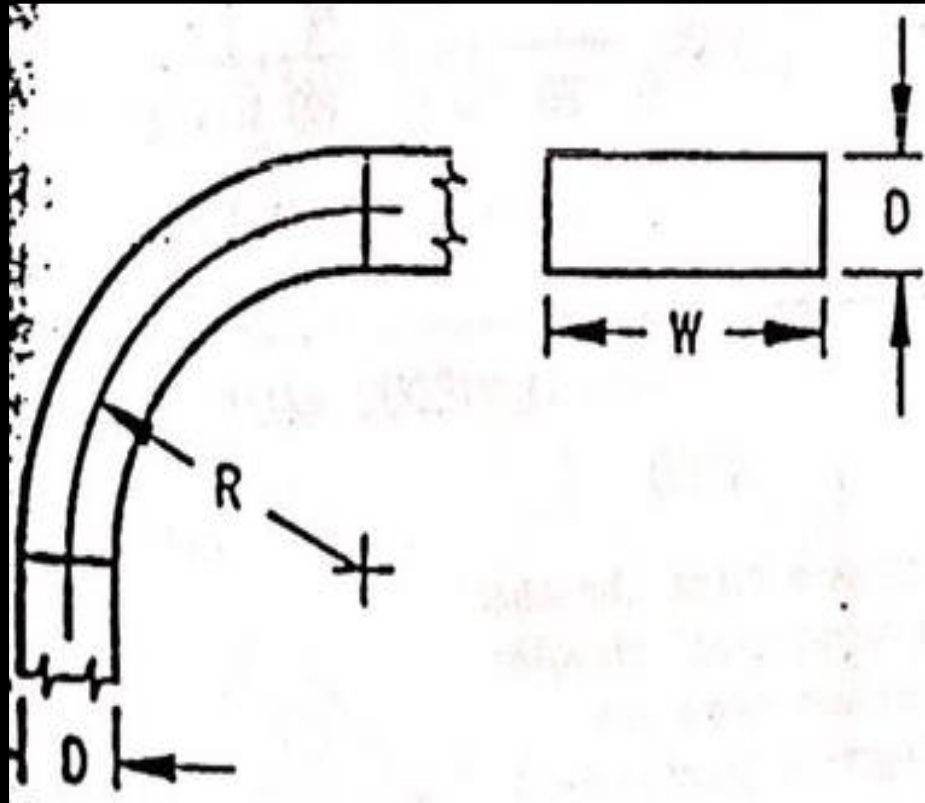
ROUND ELBOW LOSS COEFFICIENTS



| | 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:

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

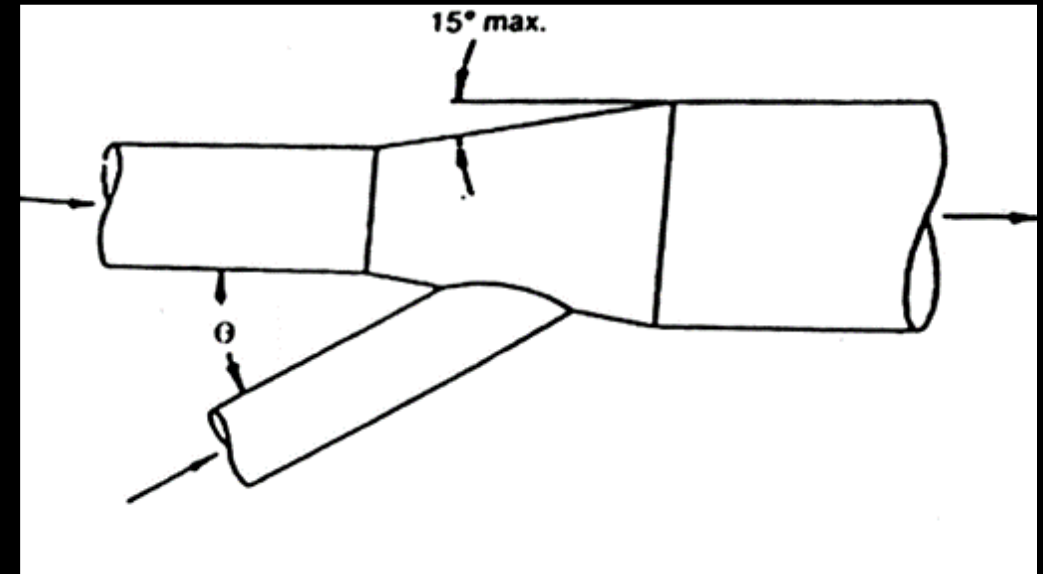
EXAMPLE FOR “ELBOW LOSS” (CONTINUED...)

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

$$0.33 \mathbf{VP}_d \times \frac{0.76 \text{ in.H}_2\mathbf{O}}{\mathbf{vp}_d} = 0.25 \text{ in. H}_2\mathbf{O}$$

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. H₂O in the previous examples is a branch duct that enters a main duct at a 30 ° angle. What is the branch entry loss?

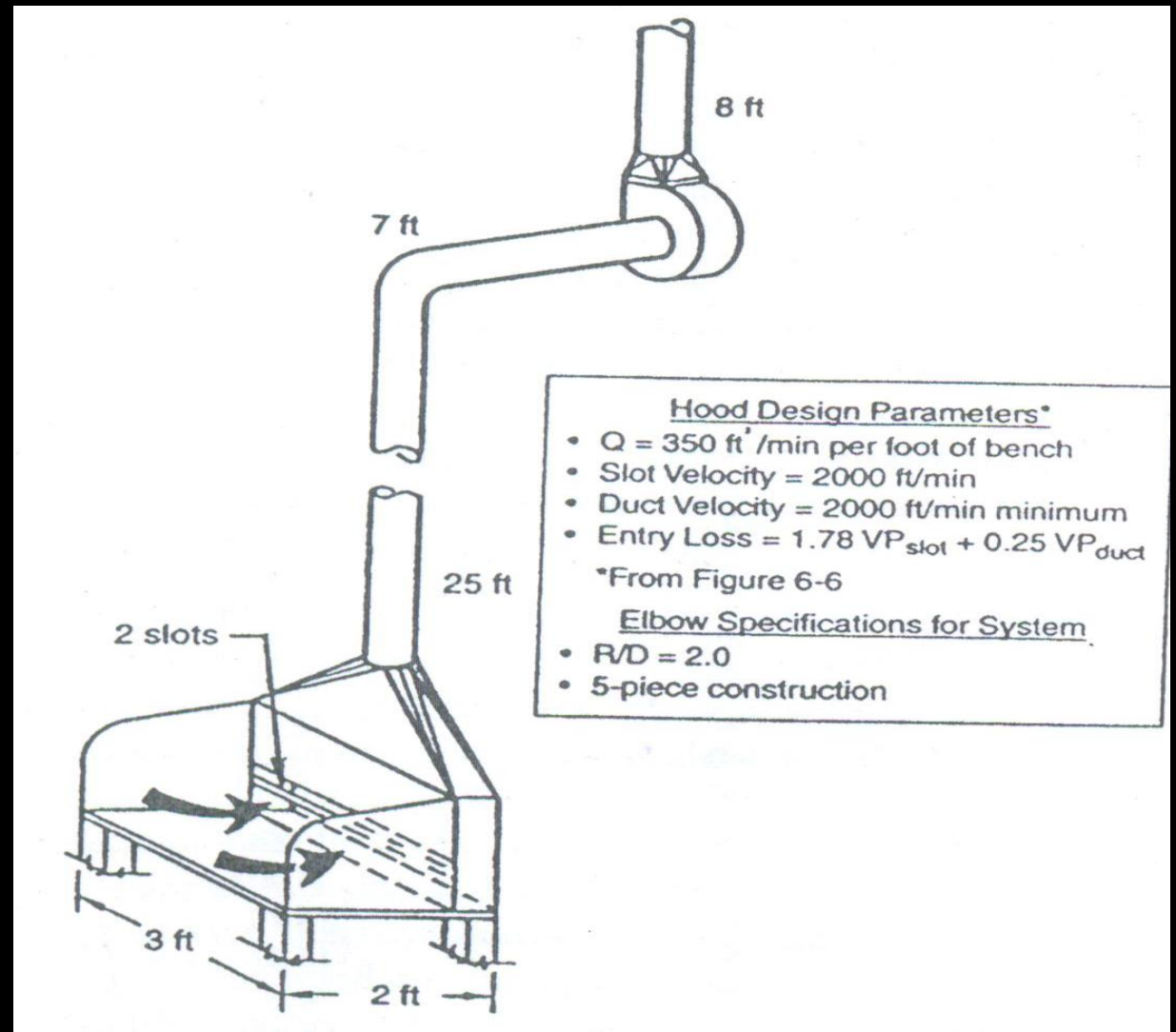
A pressure loss of 0.18 velocity pressure occurs in the 8-in. branch duct. The pressure loss is:

$$0.18 VP_d \times \frac{0.76 \text{ in.H}_2\text{O}}{vp_d} = 0.14 \text{ in. H}_2\text{O}$$

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.



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 ₂ O | | | | | |
| 9. | H O O D S U C T E N T | 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 ₂ O | | | | | |
| 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 ₂ O | | | | | |
| 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 ₂ O | | | | | | |
| 21. | Other Hood Losses | in H ₂ O | | | | | | |
| 22. | Hood Static Pressure (16 + 20 + 21) | in H ₂ O | | | | | | |

| | | | | | | | | |
|-----|--|-----------------------|--|--|--|--|--|--|
| 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 ₂ O | | | | | | |
| 35. | Other Losses (Air Cleaner, VP, etc.) | in H ₂ O | | | | | | |
| 36. | Hood/Duct Segment Loss (22 + 34 + 35) | in H ₂ O | | | | | | |
| 37. | Cumulative Static Press. at Segment | in H ₂ O | | | | | | |
| 38. | Governing Static Press. at Junction | in H ₂ O | | | | | | |
| 39. | Corrected Volumetric Flowrate | ft ³ /min | | | | | | |
| 40. | Corrected Velocity | ft/min | | | | | | |
| 41. | Corrected Velocity Pressure | in H ₂ O | | | | | | |
| 42. | Resultant VP (VP _d) (Eq. 5.11) | in H ₂ O | | | | | | |

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 | 76 | 31.50 |
| 28 | 4.276 | 78 | 33.18 |
| 29 | 4.587 | 80 | 34.91 |

SOLUTION:

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

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

3. Minimum Transport Velocity = 3000 ft/min

4. Maximum Duct Area:

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

5. Selected Duct Diameter = 8.0 in.

SOLUTION:

6. Duct Area = 0.3491 ft^2

7. Actual Duct Velocity:

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

8. Duct Velocity Pressure:

$$VP = \left(\frac{V}{4005} \right)^2 = \left(\frac{3008}{4005} \right)^2 = 0.56 \text{ in. H}_2\text{O}$$

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

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

SOLUTION:

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

11. Actual Slot Velocity:

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

12. Slot Velocity Pressure:

$$VP_{\text{slot}} = \left(\frac{V}{4005} \right)^2 = \left(\frac{2000}{4005} \right)^2 = 0.25 \text{ in. H}_2\text{O}$$

13. Slot Loss Coefficient = $1.78 VP_{\text{slot}}$

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

SOLUTION:

15. Slot Loss = $1.78 VP_{\text{slot}}$

16. Slot Static Pressure

$$1.78_{\text{slot}} \times \frac{0.25 \text{ in.H}_2\text{O}}{VP_{\text{slot}}} = 0.45 \text{ in.H}_2\text{O}$$

17. Entry Loss Coefficient = $0.25 VP_d$

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 = $1.0 VP_d + 0.25 VP_d = 1.25 VP_d$

SOLUTION:

20. Duct Entry Loss

$$1.78_{VP_d} \times \frac{0.56 \text{ in.H}_2\text{O}}{VP_d} = 0.70 \text{ in. H}_2\text{O}$$

21. Other Hood Losses: no other losses

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

$$SP_h = 0.45 \text{ in. H}_2\text{O} + 0.70 \text{ in. H}_2\text{O} = 1.15 \text{ in. H}_2\text{O}$$

23. Straight Duct Length = 32 ft.

24. Friction Loss Factor = $0.0311 VP_d/ft$ for an 8-in. duct with 3000 ft/min duct velocity.

SOLUTION:

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

26. Number of 90° Elbows = 1

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

28. Elbow Loss = $1 \text{ Elbow} \times \frac{0.19VP_d}{\text{Elbow}} = 0.19VP_d$

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 = $1.00 VP_d + 0.19 VP_d = 1.19 VP_d$

34. Duct Loss:

$$1.19_{VP_d} \times \frac{0.56 \text{ in.H}_2\text{O}}{VP_d} = 0.67 \text{ in. H}_2\text{O}$$

35. Other Losses: none

36. Hood/Duct Segment Loss = $1.15 \text{ in. H}_2\text{O} + 0.67 \text{ in.H}_2\text{O} = 1.82 \text{ in. H}_2\text{O}$

37. Cumulative Static Pressure = $1.82 \text{ in. H}_2\text{O}$

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 V_d are the same.

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

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. H₂O

35. no other losses

36. Hood/Duct Segment Loss = 0.14 in H₂O

SOLUTION:

37. Cumulative Static Pressure = 0.14 in. H₂O

38–42. Do not apply to this system

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

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

$$FSP = |1.82| + |0.14| - 0.56$$

$$FSP = 1.40 \text{ in. H}_2\text{O}$$

CALCULATION WORKSHEET FOR SYSTEM DESIGN

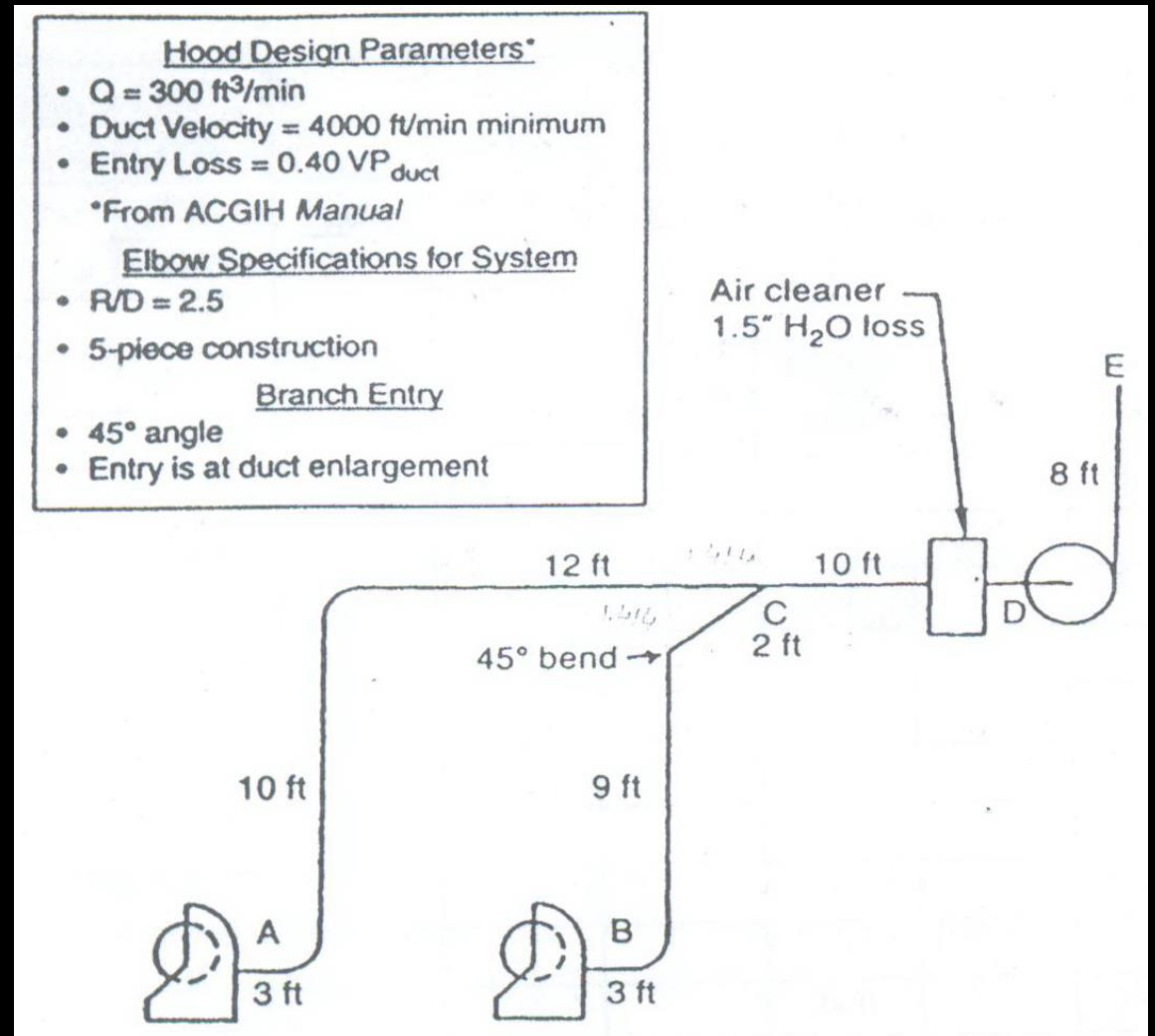
| | | | | | | | | |
|----|--------------------------------------|-----------------------|--------------------------------|----------------------|-------|--------|--|--|
| 1 | Duct Segment Identification | | Duct | | Stock | | | |
| 2 | Target Volumetric Flowrate (Q) | | ft ³ /min | 1050 | | 1050 | | |
| 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 ₂ O | 0.56 | | 0.56 | | |
| 9 | H O O D S U C T | S L O T S | 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 ₂ O | 0.25 | - | | |
| 13 | | | Slot Loss Coefficient | VP _s | 1.78 | - | | |
| 14 | | | Acceleration Factor (0 or 1) | VP _s | 0 | - | | |
| 15 | | | Slot Loss: (13 + 14) | VP _s | 1.78 | - | | |
| 16 | | | Slot Static Press. (12 × 15) | in. H ₂ O | 0.45 | - | | |
| 17 | Entry Loss Coeff. (F _e) | 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 ₂ O | 0.70 | - | | | | |
| 21 | Other Hood Losses | in. H ₂ O | - | - | | | | |
| 22 | Hood Static Pressure (16+20+21) | in. H ₂ O | 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 ₂ O | 0.67 | | 0.14 | | |
| 35 | Other Losses: (Air Cleaner, ΔVP, etc.) | in. H ₂ O | - | | - | | |
| 36 | Hood/Duct Segment Loss: (22 + 34 + 35) | in. H ₂ O | 1.82 | | 0.14 | | |
| 37 | Cumulative Static Press. at Segment | in. H ₂ O | 1.82 | | 0.14 | | |
| 38 | Governing Static Press. at Junction | in. H ₂ O | - | | - | | |
| 39 | Corrected Volumetric Flowrate | ft ³ /min | - | | - | | |
| 40 | Corrected Velocity | ft/min | - | | - | | |
| 41 | Corrected Velocity Pressure | in. H ₂ O | - | | - | | |
| 42 | Resultant VP (VP _r) (Eq. 5.11) | in. H ₂ O | - | | - | | |

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.



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 ₂ O | | | | | |
| 9. | H O O D S U C T E N T | 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 ₂ O | | | | | |
| 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 ₂ O | | | | | |
| 17. | Entry Loss Coeff. (F _θ) | 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 ₂ O | | | | | | |
| 21. | Other Hood Losses | in H ₂ O | | | | | | |
| 22. | Hood Static Pressure (16 + 20 + 21) | in H ₂ O | | | | | | |

| | | | | | | | | |
|-----|--|-----------------------|--|--|--|--|--|--|
| 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 ₂ O | | | | | | |
| 35. | Other Losses (Air Cleaner, VP, etc.) | in H ₂ O | | | | | | |
| 36. | Hood/Duct Segment Loss (22 + 34 + 35) | in H ₂ O | | | | | | |
| 37. | Cumulative Static Press. at Segment | in H ₂ O | | | | | | |
| 38. | Governing Static Press. at Junction | in H ₂ O | | | | | | |
| 39. | Corrected Volumetric Flowrate | ft ³ /min | | | | | | |
| 40. | Corrected Velocity | ft/min | | | | | | |
| 41. | Corrected Velocity Pressure | in H ₂ O | | | | | | |
| 42. | Resultant VP (VP _d) (Eq. 5.11) | in H ₂ O | | | | | | |