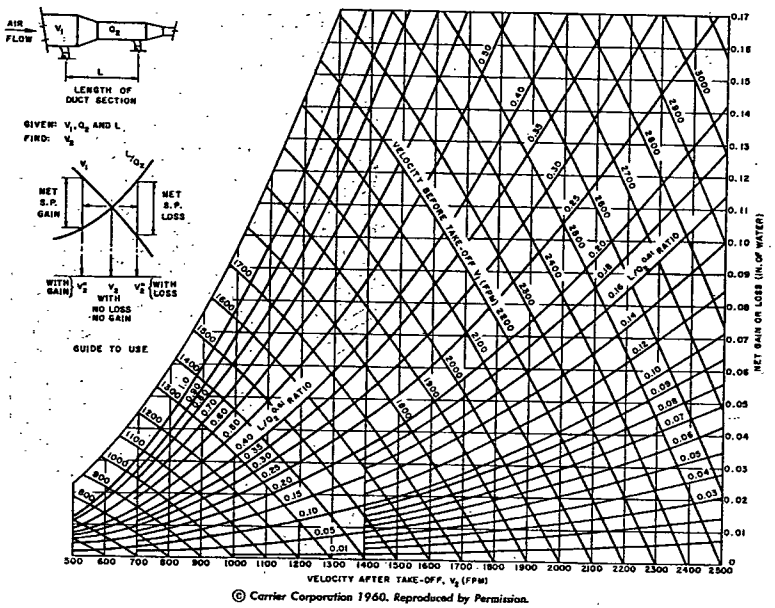


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Fig. 14 .... Static Regain Chart—For Determining Velocity after a Take-off

By use of Equation 3, the d term may be eliminated and the pressure loss expressed in terms of length, volume, and velocity.

$$H_f = 3.9 \times 10^{-3} V_2^{1.63} \left(\frac{L}{Q_2^{0.63}}\right) \quad (15)$$

As defined above, the static regain method requires that the increase in static pressure at the takeoff junction be equal to the pressure loss in the succeeding section of the run. Therefore:

$$P_r = H_f = 0.75\left[\left(\frac{V_1}{4005}\right)^2 - \left(\frac{V_2}{4005}\right)^2\right]$$

$$= 3.9 \times 10^{-3} V_2^{1.63} \left(\frac{L}{Q_2^{0.63}}\right) \quad (16)$$

In any given design, the value of V_1, Q_2, and L are known and the equation may be solved for V_2. This, in turn, permits calculation of d_2 by use of Equation 3.

Equation 16 may be solved graphically by use of Figs. 13 and 14. Fig. 13 is used to find the value of $L/Q_2^{0.63}$ and this value is then used as one of the given values in Fig. 14. Fig. 14 is a plot of two superimposed families of curves. One family of curves is a plot of V_2 vs friction drop for various values of $L/Q_2^{0.63}$, while the other is a plot of V_2 vs static regain for various values of V_1. Thus, the friction loss may be equated to the static regain and a point of *no loss-no gain* determined. This point occurs at the intersection of the V_1 curves and the $L/Q_2^{0.63}$ curves for the particular problem. To the left of this point, the distance between these two curves represents a net gain in static pressure. To the right of this point, the distance between the curves represents a net static pressure loss. See *Guide to Use* sketch in Fig. 14. This feature will be found useful when a net loss must be added to one branch of a system in order to balance the static pressure values at outlets on other branches of the duct system.

Example 7: (Static-Regain Method). The duct shown in Fig. 15 handles 8000 cfm. Determine the duct sizes in Section *A*, *B*, *C*, *D*, *E*, *F*, and *G*, maintaining an operating pressure of 0.12 in. water in the duct behind each outlet. Find the total pressure loss of the system.

Solution: The following nine steps indicate the solution:

1. Assume the velocity in Section *A* to be 1500 fpm. This results in an initial duct size of 48 × 16 in. The 16-in. duct depth will be maintained throughout the system.

2. The circular equivalent of a 48 × 16-in. duct is 29.2 in. (from Table 2), and with 8000 cfm flowing in this duct, the friction loss from Fig. 3 is 0.13 in. per 100 ft.

3. To size the ducts, determine the shortest equivalent length of duct up to the nearest outlet. Section *B* = 35 ft to outlet 1, as compared to Section *F* = 10 ft, plus equivalent length of elbow, up to outlet 6. Assume the width of the duct in Section *F* to be 15 in., therefore, $H/W = 16/15 = 1.07$. Also assume the elbow radius-to-width relation R/W to be 1.25. Then the equivalent length *L*, Fig. 8, will be 6.5 × (15/12) = 8.1 ft. Equivalent length of duct in Section *F* = 10 + 8.1 = 18.1 ft. Therefore, since *Section F* is shorter than Section *B*, size Section *F* first, using

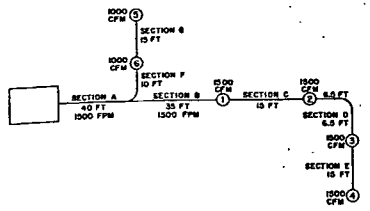


Fig. 15 .... Duct Layout for Example 7

the same friction rate as in Section *A*, 0.13 in. per 100 ft. This friction rate and 2000 cfm results in an equivalent diameter of 16.7 in Section *F*. From Table 2, the rectangular equivalent of 16.7 in. diameter duct is 15 × 16 in. This results in an average velocity of 1200 fpm in Section *F*.

Note that the shorter equivalent length is sized first to prevent the velocity in the other branches from exceeding the recommended velocities.

4. Loss in Section $F = 0.13 \times 0.181 = 0.0236$ in. water.

5. Since the operating pressure of outlet 1 is to be the same as that of outlet 6, the loss in Section *B* must equal the loss in Section *F*. Using the Static Regain Chart, Fig. 14, size Section *B* for a net loss of 0.0236 in. water. Enter Fig. 13, with 6000 cfm after take-off, proceed to 35 ft (Section *B* duct length between the take-offs) and find $L/Q_2^{0.63} = 0.18$.

Entering the regain chart, Fig. 14, with $L/Q_2^{0.63} = 0.18$ and velocity (V_1) before take-off of 1500 fpm, move to the right to obtain 0.0236 in. loss; find velocity (V_2) after take-off = 1420 fpm. (See *Net SP Loss* in *Guide to Use* in Fig. 14.)

Duct size for *Section B* = (6000/1420) × 144

= 614 sq in. = 38 × 16 in.

Actual velocity = 1420 fpm. Actual friction loss = 0.032 in. water, compensated by provision for it and static pressure regain.

6. To size Section *C*, enter Fig. 13 with 4500 cfm after take-off, proceed to 15 ft (length of Section *C*) and find $L/Q_2^{0.63} = 0.09$.

Enter the regain chart with $L/Q_2^{0.63} = 0.09$ and velocity before take-off = 1420 fpm; find for *no gain-no loss* velocity after take-off 1300 fpm.

Duct size for Section *C* = (4500/1300) × 144

= 498 sq in. = 31 × 16 in.

Actual velocity = 1300 fpm.

7. Before Section *D* is sized, the equivalent length of the elbow in this section must be determined. Assuming the width of Section *D* to be 25 in., then $H/W = 16/25 = 0.64$. Assuming R/W of the elbow to be 1.25, then the equivalent length (Fig. 8) of the elbow will be 6.0 × 25/12 = 12.5 ft. The total equivalent length of Section *D* then will be 6.5 + 6.5 + 12.5 = 25.5 ft.

Enter Fig. 13 with 3000 cfm after take-off, then move up to 25.5 ft (Section *D* length) and find $L/Q_2^{0.63} = 0.20$.

Enter the regain chart with $L/Q_2^{0.63} = 0.2$ and velocity before take-off = 1300 fpm; find for *no gain-no loss*, velocity after take-off = 1120 fpm.

Duct size for Section *D* = (1300/1120) × 144

= 386 sq in. = 24 × 16 in.

Actual velocity = 1125 fpm.

8. To size Section *E*, enter $L/Q_2^{0.63}$ chart with 1500 cfm after take-off, up to 15 ft (Section *E* duct length) and find $L/Q_2^{0.63} = 0.175$.

Enter the regain chart with $L/Q_2^{0.63} = 0.175$ and velocity before take-off = 1120 fpm; find for *no gain-no loss* the velocity after take-off = 980 fpm.

Duct size for Section *E* = (1500/900) × 144

= 200 sq in. = 14 × 16 in.

Actual velocity = 965 fpm.

9. To size Section *G*, enter $L/Q_2^{0.63}$ chart with 1000 cfm, move up to 15 ft (Section *G* duct length) and find $L/Q_2^{0.63} = 0.22$.

Enter the regain chart with $L/Q_2^{0.63} = 0.22$ and velocity before take-off = 1200 fpm, find for *no gain-no loss* velocity after take-off = 1030 fpm.

Table 8 .... Tabulation of Results (Example 7)

Section	Air Volume Cfm	Equivalent Length Ft	Average Velocity Fpm	Rectangular Duct In.	Equiv. Dia. In.	Friction Per 100 ft In. H_2O	Net Pressure Loss or Gain
A	8000	40	1500	48×16	29.2	0.130	−0.0620
B	6000	35	1420	38×16	26.4	0.120	−0.0240
C	4500	15	1300	31×16	24.0	0.110	−0.0000
D	3000	25.5	1125	24×16	21.3	0.095	+0.0003
E	1500	15	965	14×16	16.3	0.083	+0.0027
F	2000	18.1	1200	15×16	16.7	0.130	−0.0240
G	1000	15	1000	9×16	13.0	0.130	+0.0029

Duct size for Section $G = \frac{1000}{1030} \times 144 = 140$ sq in. = 9 × 16 in.

Actual velocity = 1000 fpm.

10. Total pressure loss of the system is the algebraic sum of the static pressure losses and gains. Since the system was designed basically for *no gain-no loss*, it will have only losses in Sections *A* and *B* (or *F*) and the outlet operating pressure (see Table 8).

Loss in Section *A* = 0.13 × 0.40	= 0.062
Loss in Section *B* (or *F*)	= 0.024
Outlet Operating Pressure	= 0.120
Total Pressure Loss	= 0.206 in. of water

DESIGN OF HIGH-VELOCITY DUCTS

The transmission of air at high velocities, though common in industrial exhaust systems for many years, has gained wide acceptance in comfort air-conditioning and ventilation systems only in the past few years. This acceptance is due partly to the use of improved fans and special sound-attenuation and control equipment, and partly to improved design and installation methods based upon a better understanding of the general problems connected with the design and installation of high-velocity air-conditioning systems.[19-21] For general information on these systems, see Chapters 1, 2, 3, and 4 of the 1964 Guide And Data Book

The design of high-velocity duct systems involves a compromise between reduction of duct size and the consequent necessity for higher fan horsepower. While the size of the ducts and hence the air velocities are governed in large part by the available building space, the maximum velocities given later in this section should not be exceeded without careful examination of all factors involved.

The following *general rules* will prove helpful in designing high-velocity duct systems:

1. The same general rules which apply to conventional duct design also apply to high-velocity duct design. (See Section, Design Methods.)

2. Static regain must be accounted for in high velocity systems. Latest data indicate that approximately 75 percent of the original velocity pressure can be regained if the ducts are of recommended and air-tight construction. The allowances for static regain must be made with all three duct design methods described in this chapter.

3. Proper sound control must be provided. To take care of low-frequency fan noise, a sound attenuator must usually be installed after the fan. When acoustic terminal devices are not used, attenuator chambers or sound-lined ducts must be installed after mixing valves, in order to attenuate duct and valve noise to acceptable levels.

4. Air velocities in main ducts may vary from 2500 fpm in some installations to over 6000 fpm in others. Corresponding