CHAPTER 31

Air Duct Design

Pressure Losses, Friction Losses, Friction Loss Chart, Elbow Friction Losses, Proportioning the Losses, Duct Sizes, Procedure for Duct Design, Velocities, Main Trunk Ducts, Proportioning the Size for Friction, Velocity Method, Equal Friction Method, Duct Construction Details, Duct Heat Loss and Insulation

THE resistance of an air handling system can be computed from the methods and data given in this chapter. The actual resistance for any given installation, however, may vary considerably from the calculated resistance because of variation in the smoothness of materials, the type of joints used and the ability of the mechanics to fabricate in accordance with the design. It is best to select fans and motors of sufficient size to allow a factor of safety. Volume dampers should be installed in each branch outlet to balance the system. It is improbable that the required quantities of air will be delivered at each outlet without adjustment of the dampers, which usually results in a total pressure exceeding that of the design, unless a liberal factor of safety is allowed.

The flow of air due to large pressure differences is most accurately stated by thermodynamic formulae for air discharge under conditions of adiabatic flow, but such formulae are complicated, and the error occasioned by the assumption that the gas density remains constant throughout the flow may be considered negligible when only such pressure differences are involved as occur in ordinary heating and ventilating practice.

In the development of the formulae, diagrams, and tables for the flow of air, use is made of the following basic equation for the flow of fluids:

If H_v be the velocity head in feet of a fluid, and the velocity, V, be expressed in feet per minute, the fundamental equation is

$$V = 60\sqrt{2g\,H_v}$$

The factor g is the acceleration due to gravity, or 32.17 fps per second.

It is usual to express the head in inches of water for ventilating work and, since the heads are inversely proportional to the densities of the fluids,

$$\frac{H_v}{\dfrac{h_v}{12}} = \frac{62.4}{d}$$

or

$$H_v = 5.2\,\frac{h_v}{d}$$

therefore,

$$V = 1096.5\sqrt{\frac{h_v}{d}} \qquad (1)$$

where

V = velocity, feet per minute.
h_v = velocity head or pressure, inches of water.
d = weight of air, pounds per cubic foot.

For dry air (70 F and 29.921 in. Hg barometer) d = 0.075 lb per cubic foot[1]. Substituting this value in Equation 1:

[1]See Chapter 47 for definition of standard air.

$$V = 1096.5\sqrt{\frac{h_v}{0.075}} = 4005\sqrt{h_v} \qquad (2)$$

The relation of air velocity and velocity head expressed in Equation 2 is shown diagrammatically in Fig. 1 for air at 70 F and 29.92 in. Hg barometer.

The drop in pressure in air distributing systems is due to the *dynamic* losses and the *friction* losses. The friction losses for turbulent flow (which occur in all practical air flow problems) are due to the friction of air against the sides of the duct and to internal friction between air molecules. The dynamic losses are those due to the change in the direction or in the velocity of air flow.

Dynamic losses occur principally at the entrance to the piping, in the elbows, and wherever a change in velocity occurs. The entrance loss is the difference between the actual pressure required to produce flow and the pressure corresponding to the flow produced; it may vary from 0.1 to 0.5 times the velocity head. The pressure loss in elbows must also be allowed for in the design.

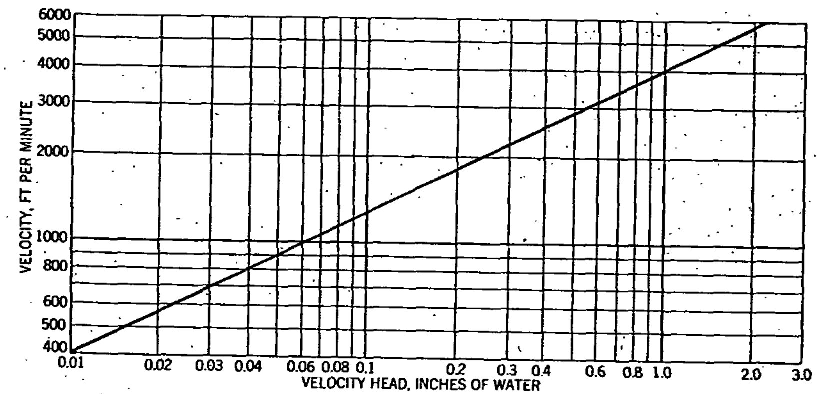

FIG. 1. RELATION BETWEEN VELOCITY AND VELOCITY HEAD FOR DRY AIR

FRICTION LOSSES

A study of the frictional resistance to the flow of air in ducts was begun by the A.S.H.V.E. Research Laboratory in 1938. This study resulted in modifications of the Fanning friction loss formula, for 100 ft of round galvanized iron duct and for air at standard conditions[2]:

For round duct with no joints,

$$H_s = \frac{1.157}{D^{1.212}}\left(\frac{V}{4000}\right)^{1.82} \qquad (3)$$

For round duct with 40 joints per 100 ft,

$$H_s = \frac{1.48}{D^{1.237}}\left(\frac{V}{4000}\right)^{1.82} \qquad (4)$$

[2]A.S.H.V.E. REPORT No. 1105—Frictional Resistance to the Flow of Air in Straight Ducts, by F. C. Houghten, J. B. Schmieler, J. A. Zalovick and N. Ivanovic (A.S.H.V.E. TRANSACTIONS, Vol. 45, 1939, p. 35). A.S.H.V.E. REPORT No. 1154—Analysis of Factors Affecting Duct Friction, by J. B. Schmieler, F. C. Houghten and H. T. Olson (A.S.H.V.E. TRANSACTIONS, Vol. 46, 1940, p. 193).