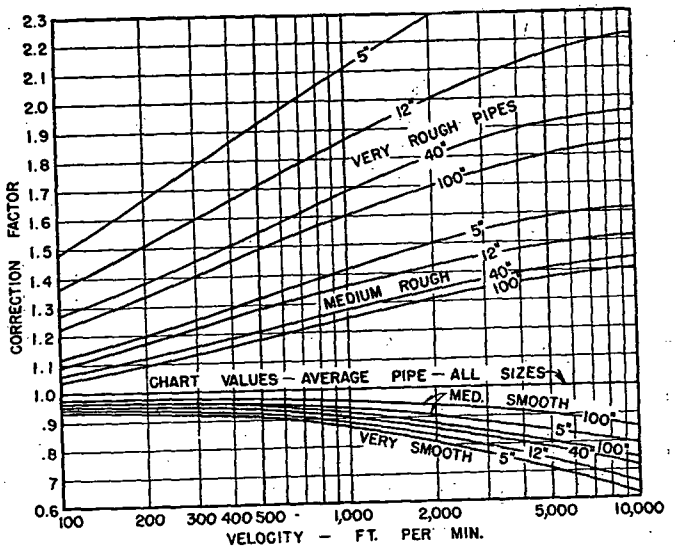

FIG. 4. CORRECTION FACTORS FOR PIPE ROUGHNESS

To correct for pipe roughness multiply friction loss obtained from Figs. 2 and 3 by correction factor obtained from Fig. 4.

construction may be determined by multiplying the losses obtained from Figs. 2 and 3 by these factors.

Accurate experimental data on the absolute roughness for flexible tubing are not yet available.

Example 1 illustrates the use of Fig. 3 to determine friction loss in a galvanized sheet metal duct. *Examples 2* and *3* illustrate the use of Figs. 4 and 5 in applying correction factors for ducts of other than sheet metal construction.

Example 1: Determine the friction loss when circulating 10,000 cfm of air through 75 ft of 24 in. diameter galvanized duct.

Solution: Find 10,000 cfm on the left scale of Fig. 3 and move horizontally right to the diagonal line marked 24 in. The other intersecting diagonal shows that the velocity in the pipe is 3200 fpm. Directly below the intersection it is found that the friction per 100 ft is 0.50 in.; then for 75 ft the friction will be $0.75 \times 0.50 = 0.38$ in. In a like manner, any two variables may be determined by the intersection of the lines representing the other two variables.

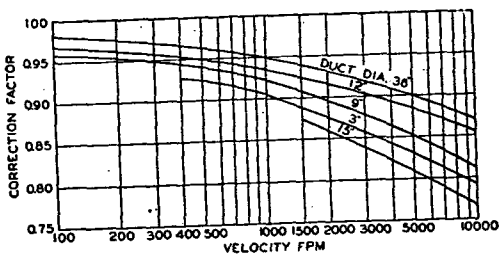

FIG. 5. CORRECTION FACTORS FOR ALUMINUM DUCT

Example 2: If the duct in Example 1 is very rough, instead of galvanized, with 40 joints per 100 ft, find the total friction.

Solution: On Fig. 4 find (by interpolation between 12 in. and 40 in. pipe) the intersection of the 24 in. *very rough pipe* line and the 3200 fpm velocity ordinate, and at the left margin read a correction factor of 2. The friction loss in the rough duct is therefore $2 \times 0.38 = 0.76$ in.

Example 3: If the duct in *Example 1* is made of aluminum, instead of galvanized iron, find the total friction.

Solution: On Fig. 5 find (by interpolation between 12-in. and 36-in. pipe) the intersection of the 24-in. line and the 3200-fpm velocity ordinate, and at the left margin read a correction factor of 0.91. The friction loss in the aluminum duct is therefore $0.91 \times 0.38 = 0.35$ in.

CIRCULAR EQUIVALENTS OF RECTANGULAR DUCTS

An air handling system is usually sized first for round ducts. Then, if rectangular ducts are desired, their sizes are selected to provide air carrying capacities equivalent to those of the round ducts originally selected.

A recent comprehensive study at the A.S.H.A.E. Research Laboratory proved that for most practical purposes rectangular ducts of aspect ratios not exceeding 8:1 will have the same static friction pressure loss for equal lengths and mean velocities of flow as a circular duct of the same hydraulic diameter. When duct sizes are expressed in terms of hydraulic diameter, and when equations for friction loss in round and rectangular ducts are equated for equal flow rate and equal length, Equation 6 giving the circular equivalent of a rectangular duct is obtained.[5]

$$d_e = 1.30 \frac{(ab)^{0.625}}{(a+b)^{0.250}} = 1.30 \sqrt[8]{\frac{(ab)^5}{(a+b)^2}} \qquad (6)$$

where

a = length of one side of rectangular duct, inches.

b = length of adjacent side of rectangular duct, inches.

d_e = circular equivalent of a rectangular duct for equal friction and capacity, inches.

Table 1 gives the circular equivalents of rectangular ducts for equal friction and capacity for aspect ratios not greater than 11.7:1 based on Equation 6.[5]

Multiplying or dividing the length of each side of a duct by a constant is the same as multiplying or dividing the equivalent round size by the same constant. Thus, if the circular equivalent of an 80- x 24-in. duct is required, it will be twice that of a 40- x 12-in. duct, or 2 x 23.0 = 46.0 in.

TABLE 1. CIRCULAR EQUIVALENTS OF RECTANGULAR DUCTS FOR EQUAL FRICTION AND CAPACITY

Dimensions in Inches

Side Rectangular Duct	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
3.0	3.8	4.0	4.2	4.4	4.6	4.8	4.9	5.1	5.2	5.4	5.5	5.6	5.7
3.5	4.1	4.3	4.6	4.8	5.0	5.2	5.3	5.5	5.7	5.8	6.0	6.1	6.3
4.0	4.4	4.6	4.9	5.1	5.3	5.5	5.7	5.9	6.1	6.3	6.4	6.6	6.8
4.5	4.6	4.9	5.2	5.4	5.6	5.9	6.1	6.3	6.5	6.7	6.9	7.0	7.2
5.0	4.9	5.2	5.5	5.7	6.0	6.2	6.4	6.7	6.9	7.1	7.3	7.4	7.6
5.5	5.1	5.4	5.7	6.0	6.3	6.5	6.8	7.0	7.2	7.4	7.6	7.8	8.0