

The volume of air in cubic feet per minute for the room is determined on the basis of the number of air changes per hour required. In the example shown, the room ventilated is a hotel dining room 135 ft x 85 ft x 15 ft. A $7\frac{1}{2}$ -minute air change (8 air changes per hour) is assumed for proper ventilation, giving 22,935 cfm as the air required.

The clear area of the fresh air inlet is based on a velocity of 1000 fpm or $\frac{22,935}{1000} = 22.94$ sq ft. If the air washer is provided with automatic humidity control, the tempering coil should raise the temperature of the entering air to 32 F. The washer with its automatic control will then raise the temperature from 32 F to 42 F. If the washer is not provided with automatic humidity control, the tempering coil must raise the temperature of the entering air to at least 55 F to allow for some temperature drop in the washer due to evaporation. The reheating coil is selected to raise the temperature of the air from that leaving the air washer to 70 F. The air washer should have a maximum velocity of 500 fpm through the clear area, which, in this case, is 46 sq ft. For more detailed information on tempering coil and air washer control, see Chapter 38.

Since the plan shows a moderately short run of main duct with no risers near the fan outlet, a fan should be selected which will have the required capacity of 22,935 cfm with a maximum velocity through the fan outlet of 1400 fpm. The outlet area, therefore, should be $16\frac{1}{2}$ sq ft.

The main pipe size should be selected to give a velocity equal to or less than the velocity at the fan outlet. Choosing a 56-in. pipe with a cross-sectional area of 17.1 sq ft, the velocity in the main pipe will be 1340 fpm. Using the friction pressure loss method this 56-in. main pipe will be taken as the basis of calculation.

Fig. 4 shows the amount of air to be handled by each section of pipe. Using the chart, Fig. 3, the pipe sizes are as shown in Table 2.

The pressure at the outlets nearest the fan will be greater than at the pipes farther along the run so that the former will tend to deliver more than the calculated amount of air. To remedy this condition, volume regulating dampers should be located at the base of each riser, or in each branch duct, and adjusted for proper distribution. At points where branches leave the main it may be advisable, depending upon the nature of the installation, to install adjustable splitters similar to that shown in Fig. 4 where the main duct divides into the 58 in. x 30 in. and 50 in. x 30 in. branches.

The rectangular equivalents are selected from Table 1; the width to depth proportion will be determined by construction requirements and ease of fabrication. The calculation of the friction is as follows:

The longest run from the fan outlet to diffuser is 150 ft 0 in.; 150 ft of 56-in. pipe is equivalent to $\frac{150 \times 12}{56} = 32.2$ diam

Two 45-in., 90-deg elbows ($2 \times \frac{45}{56} \times 8.5$)..... 13.7 diam

(At 1.5 centerline radius, pressure loss is 17 per cent of velocity head, Fig. 1, = $0.17 \times 50 = 8.5$ diameters of duct.)

Two 23-in., 90-deg elbows ($2 \times \frac{23}{56} \times 8.5$)..... 7.0 diam

TABLE 2. PIPE SIZES FOR EXAMPLE 3^a

VOLUME OF AIR (CFM)	DIAMETER OF PIPE (INCHES)	EQUIVALENT SIZE OF RECTANGULAR DUCT (INCHES)
22,935	56	60 x 44
12,510	45	58 x 30
10,425	42	50 x 30
8,340	39	42 x 30
6,255	35	42 x 24
4,170	29½	30 x 24
2,085	23	30 x 15

^aVelocity through diffusers (not shown) to be approximately 300 fpm.

Two 23-in., 90-deg elbows in riser ($2 \times \frac{23}{56} \times 30$)..... 24.7 diam
(Two bad elbows in riser, each equivalent to 30 diameters of duct.)

Total diameter of 56-in. pipe..... 77.6

The velocity head corresponding to a velocity of 1340 fpm is $\left(\frac{1340}{4005}\right)^2 = 0.112$ in.

Taking 50 diameters as one head loss, then $\frac{77.6}{50} \times 0.112 = 0.174$ in. static loss in duct.

Where the connection pieces are made with long easy slopes and the general workmanship is good, a regain in static pressure may be deducted from the foregoing pressure loss. This can be taken as approximately two-thirds the difference in velocity pressures at the fan outlet and the last run of pipe. The velocity in the riser is 667 fpm with a corresponding velocity pressure of 0.027 in. The fan outlet velocity is 1400 fpm with a corresponding velocity pressure of 0.122 in. The regain equals $\frac{2}{3}(0.122 - 0.027) = 0.063$ in.

The net static pressure loss in the duct is:

0.174 in. - 0.063 in..... 0.111 in.

Other friction losses are as follows:

- (1) Fresh air intake 1000-fpm velocity ($1\frac{1}{2}$ heads $\times 0.0625$)..... 0.094 in.
- (2) Tempering coil loss (from manufacturer's tables)..... 0.100 in.
- (3) Air washer loss (from manufacturer's tables)..... 0.250 in.
- (4) Reheating coil loss (from manufacturer's tables)..... 0.100 in.
- (5) Allowance for regulating dampers and diffusers..... 0.100 in.

Static pressure loss of system..... 0.755 in.

The fan should be selected from the manufacturer's ratings which according to the Standard Test Code for Centrifugal and Axial Fans³, will deliver 22,935 cfm at a static pressure of 0.755 in. and which has an outlet area of $16\frac{1}{2}$ sq ft.

Example 4. Fig. 5 shows an exhaust system layout for exhausting from buildings of the same type as in Example 3. Assume the air requirements based on the number of air changes per hour to be 16,800 cfm. Using a velocity of 1400 fpm in the main duct at the fan inlet, which is an average velocity for this type of system, the area of the main is 12 sq ft, which corresponds to a 47-in. pipe. Referring to Example 3, and using the chart, Fig. 3, the pipe sizes are as indicated in Table 3 for both round and rectangular ducts.

TABLE 3. PIPE SIZES FOR EXAMPLE 4^a

VOLUME OF AIR (CFM)	DIAMETER OF PIPE (INCHES)	EQUIVALENT SIZE OF RECTANGULAR DUCT (INCHES)
16,800	47	38 x 48
11,550	41	30 x 46
9,450	38	30 x 40
5,250	31	24 x 34
4,200	28.5	24 x 28
3,150	25.3	16 x 24
2,100	21.6	16 x 24

^aVelocity through intake grilles (not shown) to be approximately 400 fpm.

³See Chapters 28 and 46.