2. Sharp elbows and bends should be avoided unless turning vanes are used.

3. Transformation pieces should be made as long as possible. The angle between the sides and axis of the duct should never exceed 30 deg and, where possible, 15 deg should be made the maximum.

4. Especial care should be taken to maintain a true cross-section and not to restrict the air flow either in transformation pieces or in elbows.

5. Rectangular ducts or flues should be made as nearly square as possible. Good practice limits the ratio between the long side and the short side to 3 to 1. In no case should this ratio exceed 10 to 1.

6. Wherever possible, ducts should be constructed of smooth material such as sheet metal. Where masonry ducts are used, proper allowance for the surface friction coefficient should be made.

TABLE 2. EFFECT OF VANES ON PRESSURE LOSS OF 7-INCH SQUARE VENTILATING DUCT[a]

Expressed in feet of total equivalent length of duct (ELD)

SQUARE MITER ELBOW

Radius Ratio							
R_1/W	0	.2	.4	.6	.8	1.0
ELD, ft	41.1	30.5	27.5	30.1	37.7	38.5

Radius Ratio			
R_1/W	0	.2	.3
R_2/W	0	.4	.5
ELD, ft	41.1	23.5	23.3

Radius Ratio			
R_1/W	0	.2	.3
R_2/W	0	.4	.5
R_3/W	0	.6	.7
ELD, ft	41.1	20.7	22.2

VANE	A	B	C	D
ELD, ft	21.8	17.0	17.9	17.8

STANDARD ELBOWS WITH VARIOUS RADII

Radius Ratio						
R_1/W	0	.2	.4	.6	.8	1.0
ELD, ft	39.7	23.3	22.0	25.7	28.9	39.7

Radius Ratio						
R_1/W	0	.2	.3	.4	.5	.6
R_2/W	0	.4	.5	.6	.7	.8
ELD, ft	39.7	20.0	22.0	23.0	23.8	25.7

1½" I.R.

Radius Ratio						
R_1/W	0	.4	.6	.8	1.0	1.2
ELD, ft	25.3	17.7	16.5	18.7	23.5	25.6

4" I.R.

Radius Ratio						
R_1/W	0	.7	.8	.9	1.0	1.2
ELD, ft	14.2	13.3	13.0	12.7	12.5	12.7

[a]For more complete data see A.S.H.V.E. RESEARCH REPORT No. 1216—Effect of Vanes in Reducing Pressure Loss in Elbows in 7-Inch Square Ventilating Duct, by M. C. Stuart, C. F. Warner and W. C. Roberts (A.S.H.V.E. TRANSACTIONS, Vol. 48, 1942, p. 409).

Note A: Vane *A* made up of a large number of small splitters; *B* made up of a small number of large splitters bent on a large radius; *C* hollow vanes having different outside and inside curvature; and *D* four splitters with $R/W = 0.4$. Elbow same as *D* except 2 in. trailing edge on the end of each splitter, ELD in feet = 17.0.

Note B: The air velocity has no effect on the loss of elbows when the loss is expressed as equivalent length of duct.

7. The use of furred spaces, spaces between joists, etc., should be avoided unless lined with sheet metal.

Procedure for Duct Design

The general procedure for designing a duct system is outlined in the several items listed herewith:

1. Study the plan of the building and draw in roughly the most convenient system of ducts, taking cognizance of the building construction, avoiding all obstructions in steel work and equipment, and at the same time maintaining a simple design.

2. Arrange the positions of duct outlets to insure the proper distribution of air.

3. Divide the building into zones and proportion the volume of air necessary for each zone.

4. Determine the size of each outlet, based on the volume as obtained in the preceding paragraph, for the proper outlet velocity and throw.

5. Calculate the sizes of all main and branch ducts by either of the following two methods:

   a. Velocity Method. Select the velocity in the various sections, reducing the velocity from the point of leaving the fan to the point of discharge to the room. In this case the pressure loss of each section of the duct is calculated separately and the total loss found by adding together the losses of the various sections of the continuous run.

   b. Friction Pressure Loss Method. Proportion the duct for equal friction pressure loss per foot of length.

6. Calculate the friction for the duct offering the greatest resistance to the flow of air, which resistance represents the static pressure which must be maintained at the fan outlet or in the plenum space to insure distribution of air in the duct system. The duct having the greatest resistance will usually be that having the longest run, although not necessarily so.

Air Velocities

The air velocities given in Table 3 have been found to give satisfactory results in engineering practice. Where the higher velocities are used, the ducts should be cross-braced to prevent breathing, buckling or vibration, and should be constructed of heavier gage metal. At the higher velocities it is particularly important to design the ducts for minimum resistance. As high velocities at one point offset the effect of proper design in all other parts of the system, emphasis should be placed on the importance of air velocities, elbow design, location of dampers, fan connections, grille and register approach connections, and similar details. For industrial buildings, noise is seldom given much consideration, and main duct velocities as high as 2800 or 3000 fpm are sometimes used but, when these velocities are used, due consideration should be given to duct design, resistance pressure, fan efficiencies and motor horsepower. For department stores and similar buildings, 2000 to 2200 fpm are sometimes used in main ducts where noise is not objectionable and space conditions warrant it.

TABLE 3. RECOMMENDED AND MAXIMUM DUCT VELOCITIES

DESIGNATION	RECOMMENDED VELOCITIES, FPM			MAXIMUM VELOCITIES, FPM		
	Residences	Schools, Theaters, Public Buildings	Industrial Buildings	Residences	Schools, Theaters, Public Buildings	Industrial Buildings
Outside Air Intakes[a]	700	800	1000	800	900	1200
Filters[a]	250	300	350	300	350	350
Heating Coils[a]	450	500	600	500	600	700
Air Washers	500	500	500	500	500	500
Suction Connections	700	800	1000	900	1000	1400
Fan Outlets	1000–1600	1300–2000	1600–2400	1700	1500–2200	1700–2800
Main Ducts	700–900	1000–1300	1200–1800	800–1000	1100–1400	1300–2000
Branch Ducts	600	600–900	800–1000	700	800–1000	1000–1200
Branch Risers	500	600–700	800	650	800–900	1000

[a]These velocities are for total face area, not the net free area.

Where high velocity diffusing outlets are used, the duct velocity should not be less than the throat velocity of the diffusers, as dynamic losses