5. Calculate the sizes of all main and branch ducts by one of the three methods of sizing air supply systems in common use, the velocity reduction method, the equal friction method or the static regain method.

6. Calculate the losses for the duct offering the greatest resistance to the flow of air, using the A.S.H.V.E. *Friction Charts*, Figs. 1 and 2, and the other data given in this chapter.

Recommended Design Velocities

The air velocities given in Table 4 have been found to give satisfactory results in engineering practice. Where the higher velocities are used, the ducts should be cross-broken 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. Since 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.

Table 4. 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]	500	500	500	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	800–1200	1100–1600	1300–2200
Branch Ducts	600	600–900	800–1000	700–1000	800–1300	1000–1800
Branch Risers	500	600–700	800	650–800	800–1200	1000–1600

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

Where high velocity diffusing outlets are used, the duct velocity should be, if possible, equal to, or somewhat lower than the throat (neck) velocity of the diffuser, in order to utilize the effect of higher static pressure in the duct for equalization of air discharge.

The velocities in main ducts, and particularly in branch ducts and branch risers, should be correlated to the throat (neck) velocity of the air outlets, and manufacturers' data should be consulted for permissible throat velocity for the particular type of application.

If it is necessary to use a duct velocity that is twice the velocity for an outlet mounted on the side of the duct, a collar with directing vanes should be used to straighten the flow of air from the outlet. Sometimes it is desirable to mount the outlet flush with the side of the duct, in which case

the duct velocity should be kept below twice that of the outlet velocity, and even then an outlet larger than normally required should be used, as the entire outlet area will not be effective. Manufacturers' selection tables base sizing of outlets on required volume of air, temperature differential, and distance of throw or radius of diffusion. In following their recommendations, maxima should be avoided. See Chapter 31 for a discussion of air outlets.

DESIGN METHODS

The design of the air transmission system is generally the last step in the design of the heating, ventilating or air conditioning system, but it should always be kept in mind that the type of air transmission used will, to some extent, depend on the type of equipment used, as well as on the purpose of the system. Various factors such as zoning and zone control, and their influence on the transmission and air distribution system, are briefly discussed in Chapter 30 (Central Systems for Air Conditioning).

The methods used for the design of duct systems reflect, to some degree, certain developments in the arts of heating, ventilating and air conditioning, and it took a long time before empirical methods gave way to more refined and scientific calculations. Some engineers prefer speed and simplicity to scientific exactness, but experience is then needed and proper judgment must be exercised to prevent mistakes. Both the *Velocity Reduction Method* and the *Equal Friction Method* take no account of the static regain resulting from the difference between the velocity of fan discharge and velocities of pipe discharge, and are therefore, to some degree, approximate methods. However, they are more easily applied than the static regain method which is based on proper theory, *but is subject to an assumption (based on tests) regarding the efficiency of conversion from kinetic energy to static regain.*

1. Velocity Reduction Method

When this method is used, arbitrary velocities for the various sections of the ducts are selected, with the highest velocity at the fan outlet, and lower velocities down the run as various branch ducts are taken off the main duct. Since the quantities of air that are to be delivered through each section of the duct are known, the area of each duct section can be easily determined by using the formula:

$$A = \frac{Q_a}{V_m} \tag{17}$$

where

A = duct area in square feet.
Q_a = air quantity in cubic feet per minute.
V_m = air velocity in feet per minute.

To find the total static pressure against which the fan must operate, the static pressure loss of each section is calculated separately, and the total loss found by adding the individual losses of the sections of the duct which has the highest resistance. This may be the duct with the longest run, but not necessarily so.

The velocity method has the advantage that the duct area can be determined very easily. It should be used only for simple layouts. The air velocities given earlier in this chapter are helpful in choosing proper ve-