SOUND SOLUTIONS

PLUG FANS

No. 2

Recent trends in HVAC system design have led more and more to the use of plug fans in lieu of the more conventional scroll centrifugal fans which have dominated the HVAC industry for many decades. The reasons for this evolution are many, but before these are discussed it is important to understand how a plug fan works, and in particular, how it differs from the standard centrifugal fan.

Both the plug fan and the standard scroll centrifugal fan use an airfoil wheel or impeller to develop the system pressure and move the air. Air enters the impeller from the side inlet and is accelerated radially away from the axis of rotation. In a centrifugal fan there is a scroll which surrounds the impeller to direct the air discharge in a single direction at a relatively high outlet velocity. In the plug fan there is no scroll around the impeller, and as a result, the air discharges radially from the impeller in a 360 degree pattern. This action causes a pressurization of the fan plenum (which is usually internally lined with sound absorbing material), and the air escapes the plenum through ducted outlet holes provided in the fan housing. Figures 1 and 2 show typical longitudinal sections through the two fan types which have been arranged for a vertical, draw-through application.

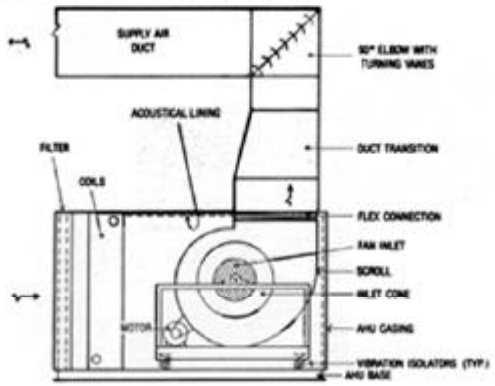

FIGURE 1. STANDARD SCROLL CENTRIFUGAL FAN AIR HANDLING UNIT

One of the main advantages of the plug fan over the standard centrifugal fan is lower discharge and inlet noise levels. The lower noise levels result primarily from the sound absorption which takes place within the fan plenum. In a standard centrifugal fan virtually all of the discharge sound power projects into the ductwork, but with a plug fan only a fraction of this noise escapes. The difference in sound power levels between a plug fan and a standard centrifugal fan operating at the same duty point will be a function of the impeller size, the fan plenum size, the size and locations of the discharge openings, the acoustical lining, and the discharge duct configuration. If the impeller is selected for maximum efficiency and the plenum is lined with 4 inch thick acoustical insulation, you can usually count on at least 10 dB less sound power in the middle frequencies (500 Hz to 2000 Hz), 5 to 10 dB less sound power in the octave bands centered at 125 Hz, 250 Hz, and 4000 Hz, and little or no change in the sound power level in the first octave band (63 Hz). This reduction is approximately comparable to the insertion loss provided by a three foot long, low pressure duct silencer.

The ability to access the fan plenum at any point with one or more ducts is another major advantage associated with the plug fan. This eliminates the need for space and materials to make transitions or splits in the ductwork close to the fan discharge. The air velocity profile at the discharge of a standard centrifugal fan is far from uniform, and duct transitions, elbows, or splits located near the fan discharge often generate more noise than the fan itself. The versatility available from the plug fan discharge plenum usually eliminates the need for these undesirable fittings. An excellent example is the common condition where an air handling unit is used to supply air to an adjacent space. Because the ductwork must be located at least 9 feet above the floor in order to be concealed behind the suspended ceiling, a conventional centrifugal fan is usually selected with a top discharge, a transition, and a 90 degree elbow or tee, all within one or two equivalent duct diameters of the fan as shown in Figure 1. The plug fan can solve these problems by allowing the ductwork to tap directly into the fan plenum at the desired elevation without using any elbows or transitions as shown in Figure 2. A more efficient use of space and lower total system pressure and noise is often the net result of the increased versatility provided by the plug fan.

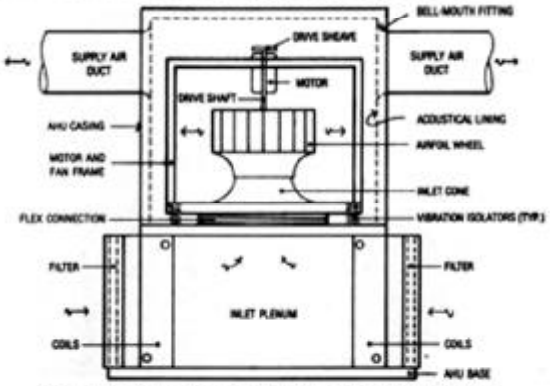

FIGURE 2. VERTICAL PLUG FAN AIR HANDLING UNIT.

There are some disadvantages of plug fans which should also be mentioned. First of all, the net mechanical efficiency of the plug fan is slightly less than the efficiency of a standard scroll centrifugal fan, primarily due to the loss of velocity pressure in the plug fan plenum because the air is not directed to the fan outlet. If noise from the fan is a concern, however, this loss in efficiency can usually be made up by the elimination of elbows, transitions, and sound traps or acoustical lining in the supply ductwork.

Vibration isolation of a plug fan is usually a little more complicated than the vibration isolation of a standard scroll centrifugal fan. This is because of the additional air turbulence set up by the free discharge of air from the exposed wheel inside the cabinet. This air turbulence causes somewhat higher casing vibration levels which can be transmitted to the supporting structure unless an isolation element is supplied between the casing framework and the supporting structure. In most situations an inexpensive neoprene rubber pad is sufficient to provide the necessary isolation. The motor, frame, and fan wheel assembly should also be internally isolated within the fan cabinet with high deflection vibration isolators.

Some general recommendations which should be applied to plug fans include:

1. Draw-through units are much preferred over blow-through units.
2. Use bell-mouth fittings and spiral round ductwork at outlets.
3. Use a two motor drive or variable speed drive with VAV systems.
4. Use 4" thick acoustical lining in the fan plenum.

There are many other factors (e.g. methods of volume control for VAV systems, location of fan rooms, initial and operating costs, etc.) which should be carefully considered before selecting a fan type for a given project. A discussion of these topics is beyond the scope which can be addressed in this article, but it would be safe to say that a properly designed and installed plug fan system can usually provide significant cost and performance advantages over a standard centrifugal fan system.