PRODUCT APPLICATION

A technical bulletin for engineers, contractors and students in the air movement and control industry

Reducing Fan Energy and Maintenance Costs by Selecting the Correct Centrifugal Fan Arrangement

Centrifugal fans are typically offered in several arrangements, that is, the position of the housing scroll and the location of the motor drive relative to the fan. When deciding on the best arrangement of a fan, four main criteria of an application can influence your selection:

1. Fan performance (flow, pressure, temperature, contents of airstream, etc.);
2. Reducing installation system effect (which increases energy consumption);
3. Drive arrangement (belt or direct);
4. Size/location (footprint size of the unit, access to various components on the fan, etc.)

Fan Performance

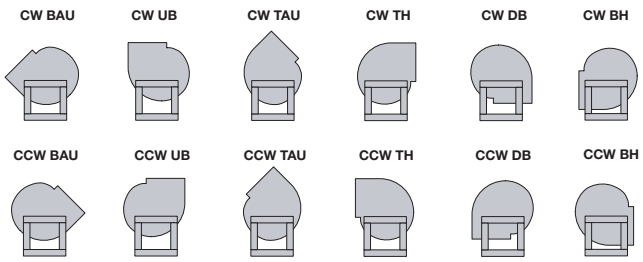
The first of the criteria is the most important, for if a fan is selected that fits in the designated area, but cannot accomplish the desired performance, then the main objective of the fan application is not addressed. One must consider the performance of the fan first, and then make any needed concessions to place it into the allowable space.

Reducing Installation System Effect

Fan inlet and outlet duct connections should be designed to minimize air turbulence which will result in lower fan speed, noise, and energy consumption. Centrifugal fans are available and can be specified and scheduled with one of 12 standard inlet and outlet locations. By selecting the proper inlet and outlet location of the fan for an application, it is possible to minimize air turbulence and the number of duct elbows reducing the system effect. All centrifugal fans are available with clockwise (CW) or Counterclockwise (CCW) rotation. Fan wheel rotation and discharge are always determined from the drive side of the fan.

Figure 1 illustrates the 12 centrifugal fan housing arrangements that are available and can be specified.

Fig. 1



Figures 2a and 2b illustrate how the correct selected housing arrangement can reduce system effect reducing energy consumption and simplifying installation.

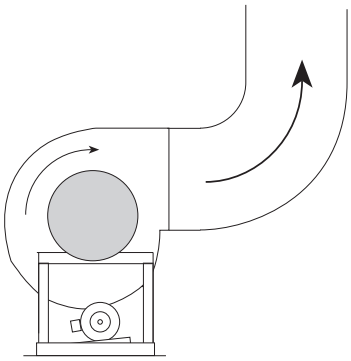


Fig. 2a
Poor

Figure 2a illustrates a poor installation with an elbow directly at the fan discharge. A proper length of straight duct between the fan outlet and this elbow is required to minimize turbulence and system effect.

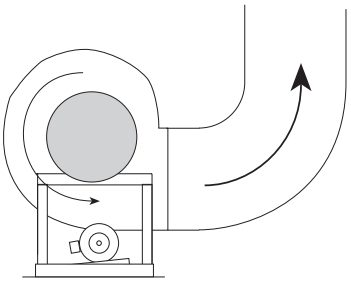
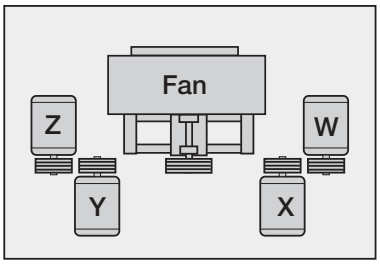


Fig. 2b
Good

Figure 2b illustrates a typical installation with an elbow directly at the fan discharge. Discharge and rotation have been selected to match the fan's field conditions of figure 2a reducing air turbulence.

Drive Arrangement and Size

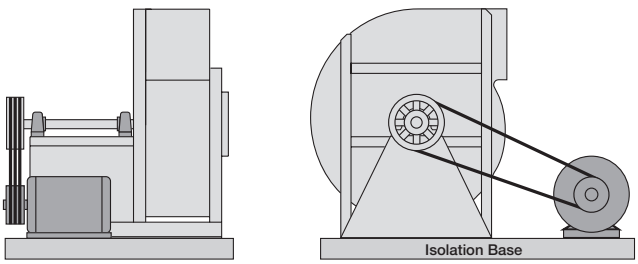
From a performance standpoint, an Arrangement 1 fan will allow the greatest flexibility. In this arrangement, both bearings are out of the airstream and theoretically, there is no limit to motor power/frame size. The allowance of any size motor means that only the fan's maximum speed and desired motor service factor will restrict your choice of motor sizes. Arrangement 1 also allows the customer the flexibility of four motor positions: W, X, Y, and Z. These choices allow the motor to be placed in a location that makes it easy to inspect and/or service and avoid any possible interference with discharge ductwork.



Motor position and fan rotation are determined from drive side

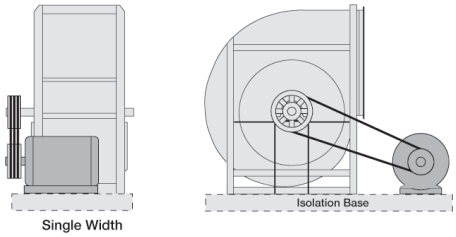
One of the drawbacks to Arrangement 1 is that it has the largest footprint and takes up the greatest amount of floor space. This can lead to increased building costs as the square footage required for the ventilation increases. Because the motor is not mounted directly on the fan, a structural base or other common element between the fan and motor is also required for this arrangement. The motor mounting on Arrangement 1 is an item that is easily overlooked on fan applications, so be sure to double-check the equipment schedule and drawings to make sure one is specified.

Arrangement 1, Single Width



Arrangement 3 fans are similar to Arrangement 1 fans in the fact that they require a structural base as the motor is not mounted directly on the fan. Again, this allows for a choice of motor positions as well as limitless motor size. The major limitation of Arrangement 3 fans comes from the location of the bearings. Arrangement 3 fans have one bearing on each side of the fan wheel which provides a very stable mount for the fan wheel. It also allows for the narrowest fan design for a given fan wheel size reducing the fan assembly footprint. When used in combination with a split housing, this arrangement is very popular for retrofit applications where the fan may need to be moved through narrow hallways, tight stairwells, or smaller personnel elevators.

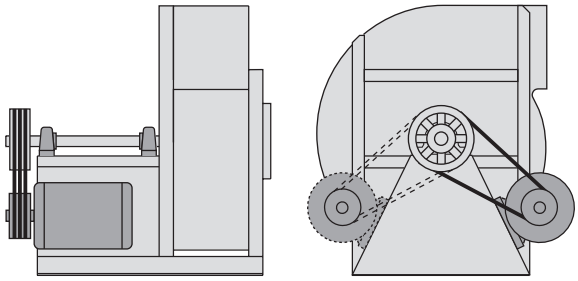
Arrangement 3, Single Width



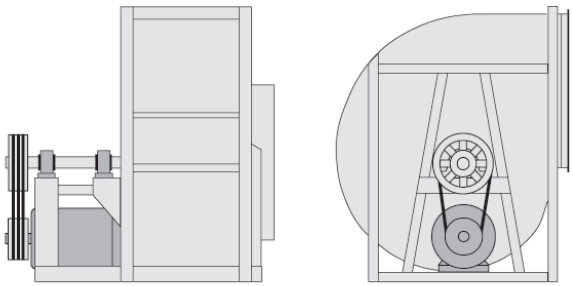
The disadvantage to this design is that one bearing is in the airstream. This limits the fan's applications to those handling clean nonhazardous air below 180ºF. In the case of a single-width Arrangement 3 fan, which is commonly ducted on the inlet, service or replacement of the bearing in the airstream can also be a concern.

Just as Arrangement 1 and 3 fans have many of the same physical characteristics, Arrangement 9 and 10 fans are also very similar to each other. In fact, the only difference from an appearance standpoint is that an Arrangement 10 fan has the motor mounted under the bearing pedestal, and an Arrangement 9 fan has the motor mounted on the left or right side of the bearing pedestal.

Arrangement 9, Single Width



Arrangement 10, Single Width

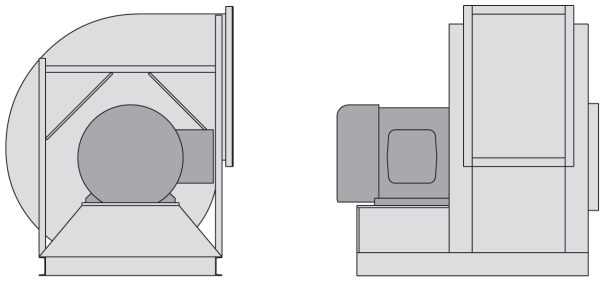


Arrangement 10 is generally the most widely used fan arrangement due to its compact footprint, constant overall dimensions regardless of motor used, and the ease in protecting the motors, drives, and bearings if applied outdoors. Arrangement 10 fans will have limitations on motor frame size slightly more stringent than Arrangement 9 because of the limited space under the bearing pedestal. In either of these arrangements, the motor attaches directly to the fan, making them very compact and easy to install. In addition to motor size, one of the other limitations of these fans is operating temperature. This is due to the close proximity of the motor to the continuous airstream. Generally, Arrangement 9 and 10 fans are limited to airstream temperatures of 500ºF or less. In the case of Arrangement 10, an insulating panel can be placed between the motor and the fan scroll to reduce heat radiation into the motor area.

Direct Drive Arrangement

Although all of the previous arrangements use a combination of belts and sheaves to turn the fan wheel, direct-driven fans may be used where reduced maintenance is desired. Arrangement 4 is the simplest design and has the fan wheel mounted directly to the motor shaft. This eliminates the pulleys, belts, and fan shaft bearings and typically leads to a much smoother running fan.

Arrangement 4, Single Width

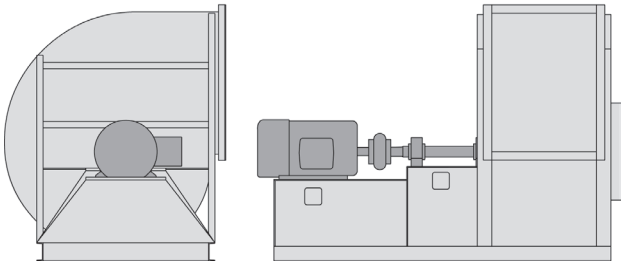


The disadvantage of this design is most noticeable when a large fan is running at a relatively slow speed. The fan horsepower may be very low, yet the motor used must be large enough to support the weight of the fan wheel. For example, a 36-inch fan may only require 5 bhp to operate but will need a 15 to 20 hp motor to ensure that the frame size is large enough to get the proper motor shaft diameter and length. This is not only a problem concerning the initial purchase cost, but the motor is also more costly to operate over the life of the fan. One way to minimize this issue, if airstream conditions allow, would be to use an aluminum fan wheel construction to reduce the weight of the wheel.

There are several other considerations involved in Arrangement 4 applications. If the fan is handling a contaminated or hazardous airstream, motor replacement is facilitated by accessing the contaminated airstream to unbolt the fan wheel from the motor. Additionally, the motor bearings must provide an acceptable L_{10} bearing life since they must withstand the radial load and axial thrust load from the fan wheel in addition to the weight of the motor rotor. The motor must also be sized to satisfy fan wheel inertia during start-up.

Since the fan wheel is directly connected to the motor shaft, the fan will run at a 60-cycle (or 50-cycle) synchronous speed. An outlet damper, inlet guide vanes, percent width wheel, or variable frequency drive must be considered as a means of control in order to obtain the design performance rating or other ratings in the system's operating cycle.

Arrangement 8, Single Width



Another solution to this is an Arrangement 8 design. This design is also directly driven via a coupling connected to a normal fan shaft and bearing combination. The advantage of this design is that the motor horsepower can be closely matched to the fan horsepower requirement. Arrangement 8 will also allow for higher airstream temperatures due to the motor being located farther from the scroll. One of the drawbacks to Arrangement 8 versus Arrangement 4 is that it has a larger footprint and takes up the greatest amount of floor space.

Summary

As a general rule of thumb for choosing a fan arrangement, try to select an Arrangement 10 fan first. If this is not applicable, consider an Arrangement 9. Again, these are the most compact fan arrangements and the easiest to install. If neither of these works, then you will have to select Arrangement 1 or 3, keeping in mind how the bearing locations will be affected by the contents of the airstream. If direct drive is desired, Arrangement 4 will give you the most compact fan, while Arrangement 8 will typically allow for smaller motor sizes.

For more information, refer to AMCA Publication AMCA 201-02 (Fans and Systems).

AMCA Certified Ratings

A manufacturer that participates in AMCA's Certified Ratings Program (CRP) assures the industry that the products and equipment will perform as stated by the manufacturer. The program stipulates the various rules and regulations for presenting cataloging data: AMCA 211 for aerodynamic performance and AMCA 311 for acoustic performance.