

# PRODUCT APPLICATION GUIDE

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

## Centrifugal Fan Arrangements

Centrifugal fans are typically offered in several arrangements, or in other words, the position of the motor relative to the fan. When deciding on the best arrangement of a fan there are three main criteria which may influence your choice:

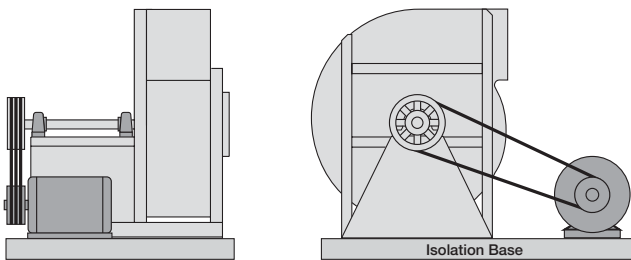
1. Fan performance (temperature, contents of airstream, etc.),
2. Drive method (belt or direct),
3. Size/location (footprint size of unit, access to various components on the fan, etc.).

The first criteria is the most important, for if you select a fan which fits in the designated area, but cannot accomplish the desired performance, then you have gained nothing. One must consider the performance of the fan first, and then make any needed concessions to place it into the allowable space.

### Belt Drive Arrangement

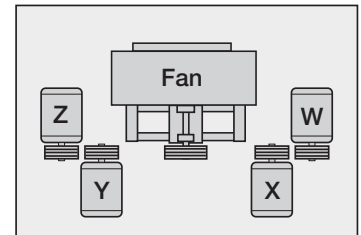
From a performance standpoint, an arrangement 1 fan will allow the greatest flexibility. In this arrangement, both bearings are out of the airstream and theoretically, there is no limit to motor frame size. The allowance of any size motor means that only the fan's maximum speed and desired motor

#### Arrangement 1, Single Width



service factor will restrict your choice of motors. 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.

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

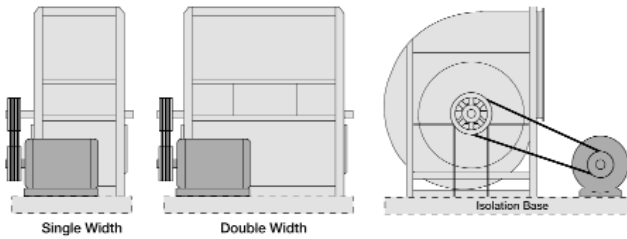


Motor position and fan rotation are determined from drive side

equipment grows. 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. This is an item that is easily forgotten on fan applications, so be sure to double check the equipment schedule to make sure one is supplied.

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 wheel. This provides a very stable mount for the wheel and allows for the narrowest fan design for a given wheel size. 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

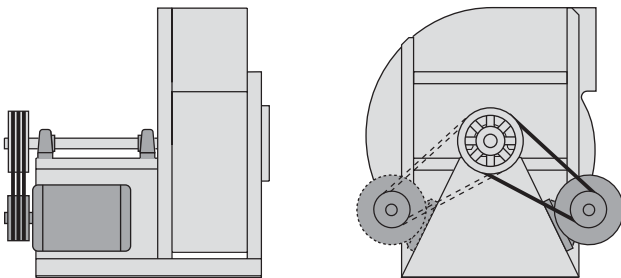
Arrangement 3, Single Width and Double Width



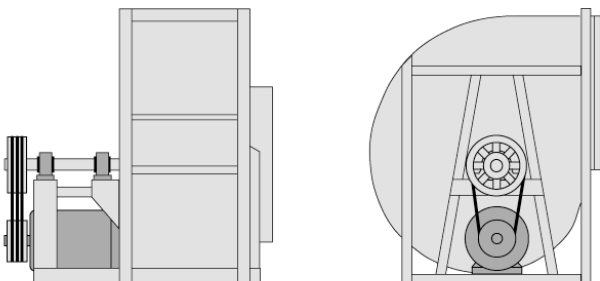
hallways, tight stairwells, or smaller personnel elevators. The disadvantage to this design is that at least one bearing (both in case of a double width fan) is in the airstream. This limits the fan's applications to those handling clean air below 180 degrees F. In the case of a single width arrangement 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

Arrangement 9, Single Width



Arrangement 10, Single Width



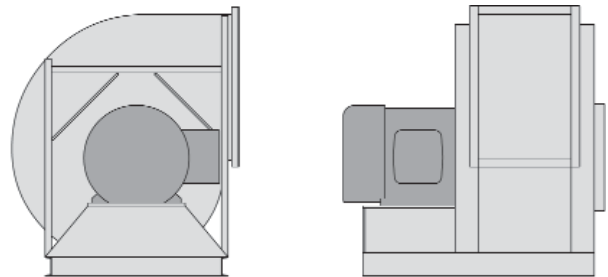
left or right side of the bearing pedestal. Arrangement 10 is generally the most widely used fan arrangement due to its compact footprint, constant overall dimensions regardless of motor used, and the ease in protecting the motors, drives and bearings if applied outdoors. Arrangement 10 fans will have 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 for 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 500 degrees F 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 pulleys to turn the wheel, direct driven fans may be used where reduced maintenance is desired. Arrangement 4 is the simplest design and has the 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.

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 wheel. For example, a 36 inch fan may

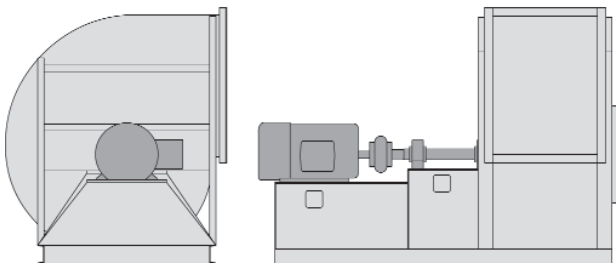
Arrangement 4, Single Width



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 product. One way to minimize the problem, if airstream conditions allow, would be to use an aluminum wheel construction to reduce the weight of the wheel.

There are several other considerations involved in Arrangement 4 applications. 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 startup.

### Arrangement 8, Single Width



Since the fan wheel is direct connected to the motor shaft, the fan will run at 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.

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 to 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.

### Summary:

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

*For more information, refer to AMCA Publication 201-90 (Fans and Systems)*

