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## Technical Services

### APPLICATION ENGINEERING BULLETIN Number # AE-002-05

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■ TOPIC: Pulley Sizing To Achieve Desired Airflow

■ SCOPE & PURPOSE:

- When belt and pulley driven blowers require an airflow adjustment it may be necessary to change the motor pulley size to achieve the correct blower RPM and CFM. This bulletin addresses the step by step procedure for determining the correct motor pulley size to obtain a given CFM of airflow.<sup>1</sup> This bulletin explains and applies the “Fan Laws” to a typical practical application. Every HVAC technician will find that learning the Fan Laws<sup>2</sup> and their application will greatly increase their ability to understand, properly adjust and troubleshoot airflow and blower systems. This bulletin includes an illustrated example.

■ CONTENT:

- Assume a supply air blower on a constant volume rooftop heating/cooling unit is currently moving 10,000 CFM of air. Also assume the airflow needs to be increased to 12,000 CFM.<sup>3</sup> The illustrated sketch on the following page shows a typical drive and driven pulley assembly for a blower with the smaller pulley on the drive motor and the larger on the blower.

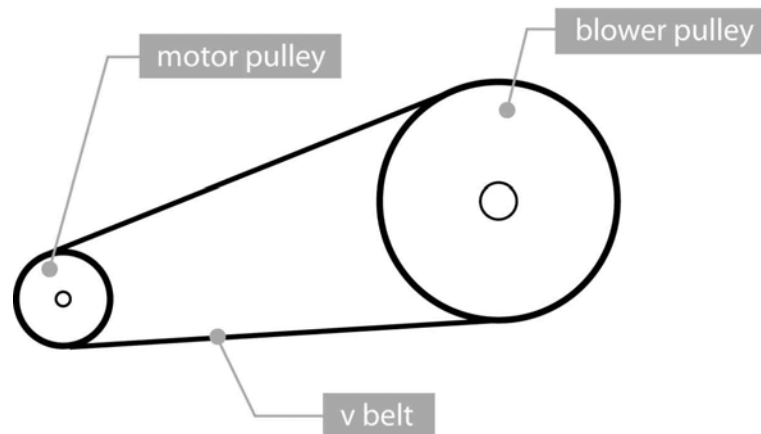
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<sup>1</sup> Airflow adjustments can only be made within the capacity range of the blower. Additionally, the airflow rate must not exceed the horsepower available from the drive motor.

<sup>2</sup> This bulletin illustrates only one of a number of valuable uses/applications of the fan laws. The series of fan laws shows the mathematical relationships between rpm, cfm, static pressure, horsepower and pulley sizes.

<sup>3</sup> Blower charts must show that the blower is capable of moving the new required airflow without falling outside of the blower curve.

## Typical Blower & Motor Pulley System



The following information about the current installation is determined;

■ Motor pulley diameter:	6-inches <sup>4</sup>
■ Blower pulley diameter:	16-inches
■ Motor nameplate RPM:	1750 RPM
■ Motor nameplate Horse Power:	7.5 HP
■ Motor Brake Horse Power <sup>5</sup> :	5.25 HP <sup>6</sup>
■ Current airflow rate:	10,000 CFM
■ Desired airflow rate:	12,000 CFM

It is desired to raise the airflow rate from the current 10,000 CFM to 12,000 CFM. The next step in the process is to determine the current blower speed (RPM) at the current airflow rate of 10,000 CFM. The blower RPM is a ratio of the motor RPM and the pulley sizes. The following "Fan Law" is used to determine the blower RPM.

<sup>4</sup> Note; Pulley diameters have two dimensions, the larger outside diameter and the actual diameter where the belt rides. The actual operating diameter is where the belt rides regardless of the outside diameter. This actual operating belt diameter is called the "PITCH DIAMETER" and is the measurement used in all calculations. It is also the diameter used in most pulley catalogs.

<sup>5</sup> Brake Horse Power (BHP) is the actual operating horsepower at a given condition. In this case, the BHP is the operating horsepower before a pulley change is made. If the BHP is already near or at the nameplate HP, no increase in airflow can be made with the current motor. A motor of higher rated HP will be required. ~~Another Application Engineering Bulletin covers the process of calculating the new required HP when the present drive motor is insufficient.~~

BHP for an installation can be calculated from measured values. ~~Another Application Engineering Bulletin covers how to determine the actual operating (BHP) for an installation.~~

<sup>6</sup> In this example the motor nameplate HP (7.5) is what the motor is capable of working at while the BHP is what the motor is actually loaded to under the current operating conditions. The BHP is a calculated value using the measured values of voltage, current, power factor and motor efficiency.

$$\frac{\text{RPM}_A}{\text{DIA}_B} = \frac{\text{RPM}_B}{\text{DIA}_A}$$

Diameter A represents the diameter of the motor pulley while diameter B represents that of the blower. RPM A is the RPM of the motor (Taken from the motor nameplate) and RPM B is the blower speed which is what we are about to calculate. Insert the known information from our example as follows;

$$\frac{1750}{16''} = \frac{\text{RPM}_B}{6''}$$

To solve for the missing value, simply cross multiply and divide.<sup>7</sup> Cross multiplying 1750 times 6 equals 10,500. Dividing 10,500 by 16 gives us the current **blower RPM of 656..** We now have determined that the blower moves 10,000 CFM at 656 RPM. We now need to determine what new blower RPM is required to raise the airflow rate from the current 10,000 CFM to the desired 12,000 CFM.

$$\frac{\text{CFM}_1}{\text{CFM}_2} = \frac{\text{RPM}_1}{\text{RPM}_2}$$

<sup>7</sup> Ratio problems containing three known and one unknown factors may be easily solved by simply "Cross multiplying and dividing". Such problems cannot be done incorrectly. Cross multiply first, then divide by the only number remaining. It is impossible to cross multiply a number times an unknown value. Just cross multiply the only two known values then divide by the remaining known value.

CFM<sub>1</sub> is the current airflow rate of 10,000 CFM and CFM<sub>2</sub> is the new desired airflow rate of 12,000 CFM. RPM<sub>1</sub> is the RPM of the blower at the existing 10,000 CFM. Cross multiplying and dividing yields the new required blower RPM necessary to move the desired 12,000 CFM of air.

$$\frac{10,000}{12,000} = \frac{656}{\text{RPM}_2}$$

Cross multiplying 12,000 times 656 equals 7,872,000, divided by 10,000 gives us the new required blower RPM to move 12,000 CFM of 787 RPM. Increasing the blower speed from 656 RPM to 787 RPM will raise the airflow from 10,000 CFM to 12,000 CFM.

The next step is to determine the new motor pulley size required to increase the blower speed and resulting airflow. This is accomplished by going back to the first fan law equation used in this paper and input the new desired values from the last two steps.

$$\frac{\text{RPM}_A}{\text{DIA}_B} = \frac{\text{RPM}_B}{\text{DIA}_A}$$

$$\frac{1750}{16"} = \frac{787}{\text{DIA}_A}$$

Notice that the motor RPM remains the same and the blower pulley size remains the same. Inserting the new desired blower RPM allows us to calculate the required replacement motor pulley diameter. Cross multiplying 16 by 787 equals 12,592 and

dividing that by 1750 gives us the new motor pulley size required to move 12,000 CFM of air. A 7.195" motor pulley diameter is required. For practical purposes the pulley size is rounded off to the nearest pitch diameter listed in the pulley catalog.<sup>8</sup>

**WARNING:** Simply changing the motor pulley from the existing diameter of 6" to a 7.2" diameter is no guarantee that the motor is capable of moving the additional airflow without overloading the motor. The new required HP may be calculated so as to know if the existing motor will be able to handle the additional airflow. The new required HP calculation is covered in an additional Application Engineering Bulletin.

If the motor pulley is changed it is essential that the new motor amperage be measured and checked against the motor nameplate amperage. The motor should not be allowed to operate above the listed full load nameplate amperage.

#### ■ SUMMARY/CONCLUSION:

- A required change in airflow may require a change in motor pulley size. The motor pulley size required to achieve a given airflow rate may be calculated using two common fan laws. An example problem showing each step of the calculation process has been included in this bulletin.
- Changing the motor pulley to a larger size will cause the motor to work harder (At an increased BHP) which could overload the motor and cause damage. Therefore, it is necessary to ensure that the motor's rated HP and amperage are not exceeded.<sup>9</sup>

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#### ■ KEY WORDS (For searches)

- Pulley
- Pulley sizing
- Sheaves
- Sheave sizing
- Airflow
- Fan laws
- Pitch diameter
- Blower adjustments
- CFM

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<sup>8</sup> Pitch diameter is the actual diameter as measured where the belt rides as opposed to the outside diameter of the pulley. Catalogs generally list the diameters as pitch diameters. Variable pitch (Adjustable Pitch) pulleys may be used but it should be understood that variable pitch pulleys cause greater wear on belts.

<sup>9</sup> The motor Brake Horsepower increases by the cube of the increase in blower RPM and/or CFM. A small change in blower speed results in a large change in the required motor horsepower!