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**HVAC Motor Doctor®**  
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## Determining Speed for AC Induction Motors

One way to determine that you are making good replacements in the field is to understand the concept of motor speed so that you can match the speed of one AC induction motor to another. At the same time, you also need to be familiar with the concept of poles, since poles represent one key to a successful replacement.

Let's begin the discussion by describing what causes an AC induction motor to run at a particular speed. Every AC induction motor has poles, just like a magnet. Unlike a simple magnet, these poles are formed by bundles of magnet wire (called windings) wound together in slots of the stator core. In most cases, you can look inside the motor and count the number of poles in the winding: they are distinct bundles of wire, evenly spaced around the stator core.

The number of poles, combined with the alternating current line frequency (HZ), are all that determine the no-load revolutions per minute (RPM) of the motor. So all four-pole motors run at the same speed under no-load conditions, all six-pole motors run at the same speed, and so on.

The mathematical formula to remember in helping make these calculations is the number of cycles (HZ) times 60 (for seconds in a minute) times two (for the positive and negative pulses in the cycle) divided by the number of poles.

Therefore, for a 60 hertz (cycles) system, the formula is:  
 $60 \times 60 \times 2 = 7,200$  no-load RPM divided by the number of poles.

For a 50 hertz system, the formula would be:  
 $50 \times 60 \times 2 = 6000$  no-load RPM divided by the number of poles.

Using this formula, you can see that a four-pole motor operating on the bench under no-load conditions runs at 1,800 RPM (7,200 divided by four poles). Note that when an AC motor is loaded, the spinning magnetic field in the stator does not change speed. Instead, the rotor or moving part of the motor is restrained by the load from "catching up" to the field speed. The difference between the field speed of 1,800 RPM in this example and the rotor speed of approximately 1,725 RPM is called the "slip." The slip varies with the load over a narrow operating range for each motor design.

So, going back to our spinning four-pole motor, it operates at 1,800 RPM under no-load conditions and approximately 1,725 RPM under load. Motors of this speed are commonly found in belted applications such as blowers, fans, air-handling equipment, compressors, and some conveyors.

A two pole motor operates at 3,600 RPM (7,200 divided by two) unloaded and approximately 3,450 RPM under load. Two-pole motors often are found in pump applications, such as sump pumps, swimming pool pumps, or water recirculating equipment. One thing to keep in mind in the field is that the higher the RPM, the "noisier" a motor may sound to the untrained ear. It is beneficial to become aware of the different speed-related sounds motors make.

Six-pole motors run at 1,200 RPM unloaded (7,200 divided by six) and between 1,050 and 1,175 RPM loaded. They are often used for air-handling equipment, direct-drive applications, window fans, furnace blowers, room air conditioners, heat pumps, and other equipment where the relatively slower motor speed makes for quieter operation. All can come in either totally open, totally enclosed, or combination models, adding to their versatility.

To satisfy consumers' desires for quieter motors, manufacturers have developed eight-pole motors. These operate at 900 RPM (unloaded) and approximately 800 RPM under load. They are being used in applications where customers expect quieter operation, such as room air conditioners and outdoor heat pump applications.

Less-common pole configurations include 12-pole motors (600 RPM) that are used in applications requiring slow speeds, such as washing machines, and 16-pole motors (450 RPM unloaded), often found in ceiling fans.

When making replacements, there is one key thing to remember: always select a replacement motor with the same number of poles as the original. If you change from a four-pole motor to a six-pole model, the RPM will be different, affecting the motor's performance. Understand that nameplate speed is an approximation of the rotor speed under load. You can tolerate some variation here, since motors are designed to accommodate a range of loaded speeds. If the other characteristics match (nameplate amps, etc), and the pole count in the same, you have a suitable replacement.

Learning to understand the relationship between motor speed and poles will help you become a more knowledgeable and effective service technician in the field.