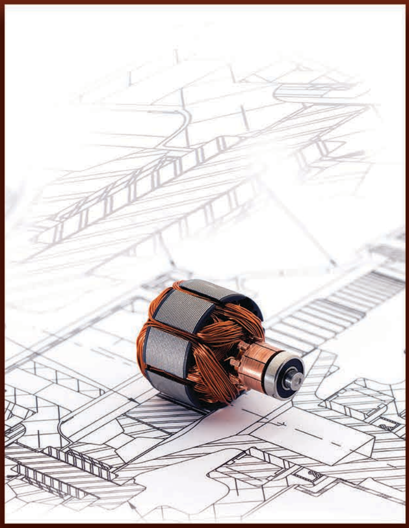
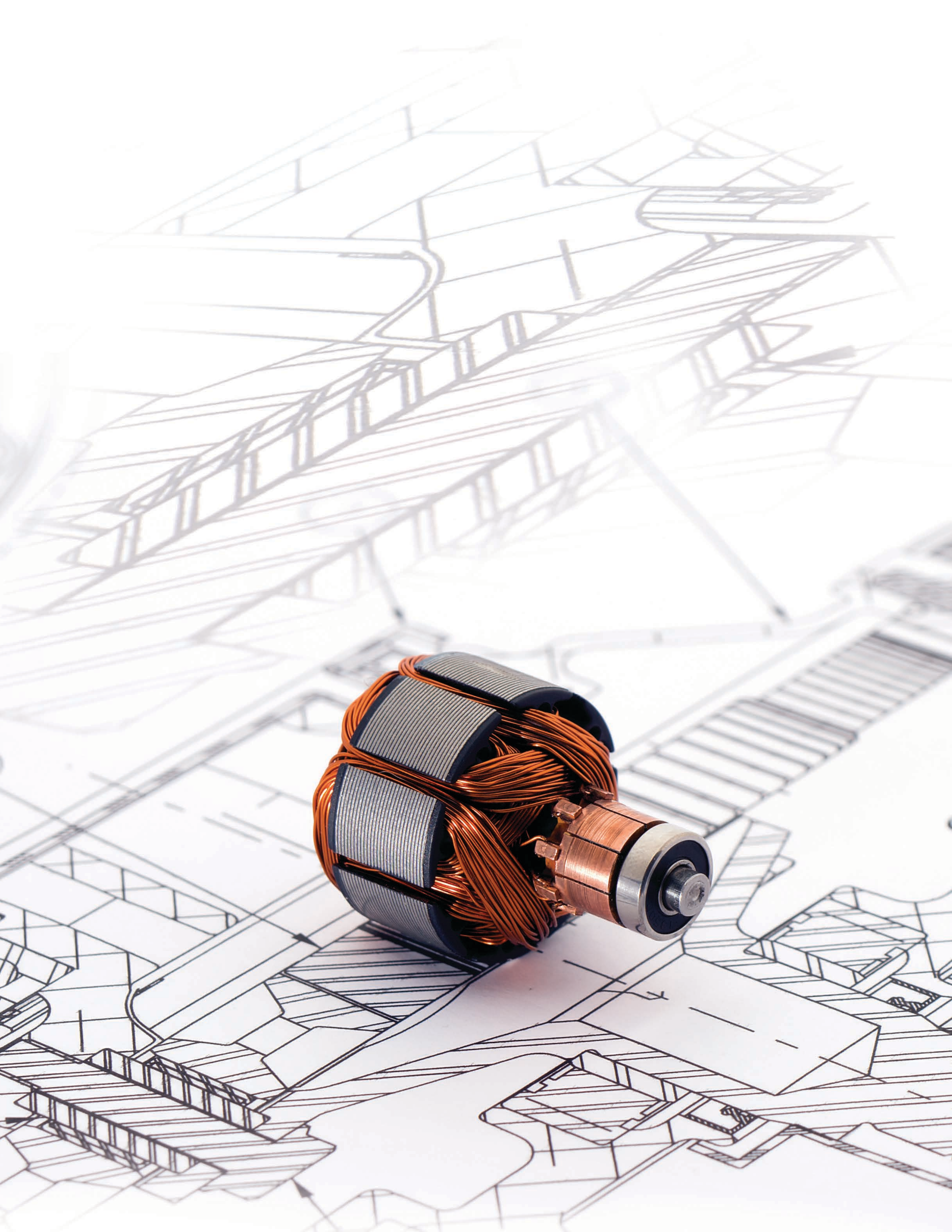
Chapter 11

Motors





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Use the time stamp on each page to navigate.

Chapter 11

Motors

Introduction

There are a number of electric motors in a heating system. Line voltage motors are used:

- In burners to drive the fuel unit and the burner fan
- In hot water systems to power the circulators
- In forced warm air and air conditioning systems to turn the fan

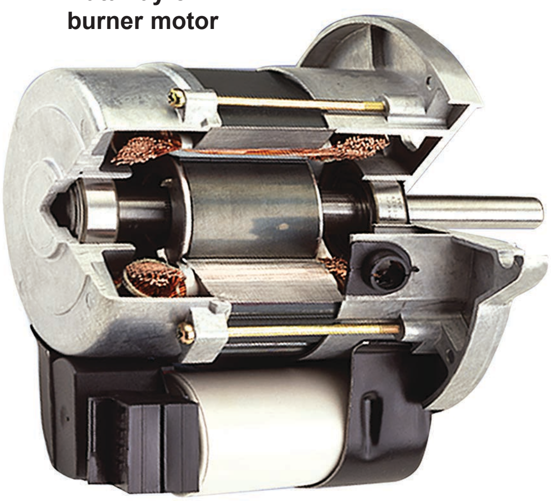
In addition, low voltage motors open and close zone valves and damper motors.

Burner motors

Residential and light commercial burners are generally equipped with 120-volt AC motors.

The flange end of the motor is designed to bolt onto the burner housing. Although most burner manufacturers use the same size flange mount, some are different.

Cutaway of burner motor



Generally, the 3450 RPM burner motor has an "M flange" with a circumference of 6¾". Older 1725 RPM burners and small commercial burners typically use an "N flange" that measures 7¼". There are also some older burners in the field that have custom flanges.

Motors are typically rated by voltage, amp draw, frame size and horsepower. The motor rating plate provides this information, Figure 11-1.

Figure 11-1: Motor rating plate

The end of the motor around the shaft is the shaft bell and the other end is known as the end bell. The type of shaft bell can affect air pressure and flow of a burner. Shaft bells with fewer air holes generally provide higher static pressure, Figure 11-2. A reduction in static pressure and flow can negatively impact burner operating characteristics. Because of this, a complete combustion analysis must be performed when replacing a burner motor.

Figure 11-2: Closed & Open Shaft Bells

Motor oiling

The majority of burner motors do NOT need to be oiled; they are "permanently lubricated."

However, motors that require lubrication should be oiled according to their duty

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cycle using the manufacturers specified lubricant, typically non-detergent SAE 20 oil.

Locked rotor amperage

Figure 11-3: Locked rotor amperage

This is the amount of amperage that can be measured for the brief instant when the motor first starts. A motor will draw substantially more amperage on the start than it will while running. After starting, the motor should only draw the amount of amperage listed on the motor nameplate. The locked rotor amperage (not usually listed on the motor nameplate), is the amount of current present if the motor fails to start after current is delivered to it, Figure 11-3.

Capacitor start motors

Capacitors are used to build up an electric charge and store it until it is needed. A capacitor start motor is capable of a much greater starting torque than a standard motor. While they are not normally used with residential burners, many commercial burners and circulators use capacitor start motors.

Thermal or motor overload switch

A thermal (or overload) switch is activated (opens) when an unusual increase in temperature occurs inside a motor to protect it from being damaged by overheating.

Before condemning a motor that doesn‘t turn, check to be sure that the fuel unit is not seized

If the motor overheats, the switch will open and turn it off. There are two types used in burner motors:

1. **Automatic reset** is the most common and will reset itself (close) after the motor cools down.
2. **Manual reset switches are found on older motors** and must be restored to operation by pressing a reset button. Figure 11-4.

Figure 11-4: Manual reset switch

Thermal overload switches trip due to either internal failure or external loading conditions.

The following will cause motor overload:

1. The line voltage is too high or too low.
2. The fuel unit has become bound or difficult to rotate.
3. The fuel unit’s return line is plugged.
4. The motor bearings are bad.
5. There is misalignment of the motor to fuel unit. (The mounting bolts may have loosened, causing improper seating of the motor or fuel unit to the burner housing).
6. The coupling is too long, putting

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pressure on the motor shaft which causes it to bind.

7. The burner fan is jammed.
8. There is dirt in the motor cooling vents causing the motor to overheat.
9. The motor is undersized. If the load requirement exceeds the nameplate rating for horsepower (HP), the motor will eventually overheat. Use a clamp around ammeter, Figure 11-5, to make sure the motor current does not exceed 10% over the motor nameplate current.

Figure 11-5: Ammeter

PSC (Permanent Split Capacitor) motors

All new burners and most burners in the field use PSC motors. Older burners used split-phase motors, but most have been replaced by PSC motors that perform with better efficiency, offer equal or increased power output and have lower starting and running current than conventional split phase motors. See Figures 11-6 and Table 11-1.

Figure 11-6: PSC motor

PSC motors are also frequently used in air handlers and blowers where a variable speed is desired.

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Troubleshooting PSC motors

PSC motors have two major areas to troubleshoot—the capacitor and the windings. Both are relatively simple to check and require only a multimeter with a capacitance range, Figure 11-7. A PSC motor trouble shooting checklist is provided at *https://learning.noraweb.org/motors.*

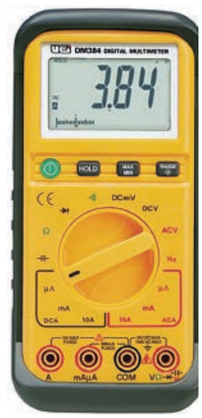

Figure 11-7: Multimeter with a capacitance range.

Table 11-1: Heating system motor testing chart (courtesy Beckett Corp.)

Test Parameter	Split Phase	PSC	Comments
Average starting current (locked rotor current)	15-25 Amps	7 Amps	PSC has a decreased starting current, which extends primary control relay life.
Average running current	2.0 - 2.4 Amps	1.5 Amps	PSC draws an average 30% less current.
Approximate starting torque	55 - 70 oz-in	49 oz-in	General mini pump starting torque requirement: 13 - 20 oz-in. [1]
Average electrical power	200 Watts	170 Watts	PSC draws an average 15% less power.
Efficiency	40 - 50%	60 - 65%	Efficiency = output power (mechanical) divided by input power (electrical)
AFG full load speed	3375 - 3450 rpm [2]	3440 - 3460 [2]	PSC: Similar or increased output power.

[1] Most standard fuel pumps (for instance, the Suntec A or B models) do not require as much power or starting torque as the larger pumps (for instance, Suntec J and H models), which often are provided with a 1/5 hp motor.

[2] **Rule of thumb:** Air flow (cfm) is proportional to motor speed, and static pressure varies with the motor speed *squared* (if the speed increases by 2%, the pressure increases by 4%).

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Checking capacitors—A failed capacitor will cause a PSC motor to either stop or run more slowly than designed. The thermal protector will trip if a restart is attempted. To check a capacitor, perform the following steps:

1. Remove power from the burner and carefully disconnect the two leads from the capacitor terminals.

2. Discharge the capacitor. *To safely discharge the capacitor, follow the instructions on page 125 in Chapter 8,* Basic Electricity.

Caution:
Failure to properly discharge a capacitor can cause physical harm due to electrical shock.

3. Using the multimeter on the ohms scale, observe the meter's response when the leads of the meter are connected to the terminals.
Note: Because the meter slightly charges the capacitor in order to make a resistance measurement, be sure to discharge the capacitor again (step 2) if the measurement is repeated.

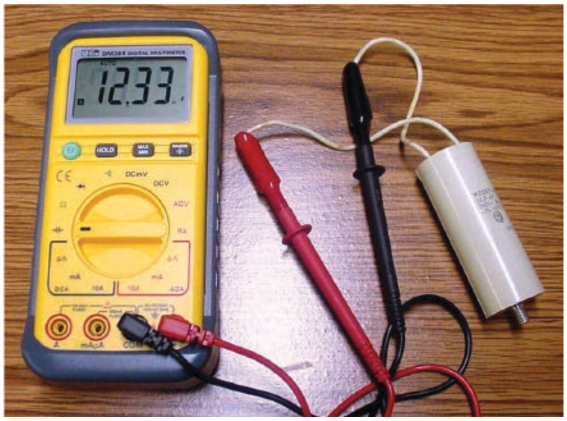
4. The ohmmeter reading should jump immediately to a non-infinite resistance value and then quickly increase again to infinity. This should happen in a fraction of a second since the capacitor will charge quickly and then resist any more charge. If the meter settles to zero ohms, the capacitor has short-circuited. If the meter resistance is infinite the entire time, the capacitor is open circuited. A failed capacitor (open or short circuited) should be replaced by a capacitor of the same capacitance (microfarads or µF) and a voltage rating at least as great as the original one. In most cases it is best to replace the entire motor.

Test tip: The quick capacitor response is more easily observed with an analog "needle" meter, than a digital meter, Figure 11-8. With a digital meter, the resistance reading should gradually increase to infinite resistance (either quickly or slowly, depending on the meter).

Figure 11-8: Analog "needle" meter

Alternate capacitor check. After discharging the capacitor, use the capacitance function of the multimeter to determine the microfarad output of the capacitor. The reading should be between 5 to 10% of the rating. Figure 11-9.

Figure 11-9: Multimeter



Checking the PSC motor windings:

1. Remove power from the burner and detach the motor power leads from the burner.

2. Discharge the capacitor and disconnect the two leads from the capacitor terminal.

3. Connect one ohmmeter lead to the

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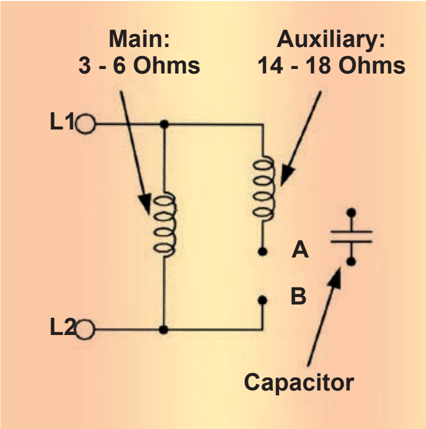
L1 motor power lead and the other meter lead to each of the capacitor leads, one at a time. Figure 11-10.

Figure 11-10: PSC Motor wiring



4. Record the two resistance values.
5. Repeat by measuring the other motor power lead (L2) and each of the capacitor leads, one at a time.
6. Check with the manufacturer's instructions. From one of the power leads, you should have measured 3-6 ohms and 9-18 ohms. From the other power lead, you should have measured a short (less than 1 ohm) and 17-24 ohms. If you do not observe these resistances, the motor windings are faulty, and the motor should be replaced.

Things to look for:

- Check all wiring to verify that it is in good condition
- Make sure the motor is aligned with the fuel unit and the coupling is tightened
- Make sure the motor is operating within the proper amp ratings
- Make sure voltage is correct

When choosing a new motor

Generally, heating system motors are designed to be non-serviceable items that must be replaced when they fail. When replacing a motor, look for the following:

1. Correct voltage.
2. Correct rotation. Some motors have reversible rotation. Change if necessary. Run the motor without the load to verify rotation is correct before connecting the load.
3. Frame designation, size, and mounting type. Example: most standard 1725 RPM burner motors are frame type 48N and most 3450 RPM burner motors are 48M frame.
4. Is the speed of the new motor the same as the old?
5. Horsepower is at least the same as the old.
6. Shaft diameter and length must be the same as the old motor, or at least long enough and the proper diameter to securely couple to the fuel unit. Bushings are sometimes used to increase the diameter of the shaft.
7. Rated amperage must be at least as high as the manufacturer's specifications.

Replacing a burner motor

The specified motor for most burners is either the closed-end type or models with small cooling openings in the shaft bell. The small openings are satisfactory as long as they are covered when the fan wheel is installed onto the motor. The back plate of the fan wheel must be positioned close to the motor end bell according to the manufacturer's gap setting for maximum efficiency and output. See Figure 11-11, on following page.

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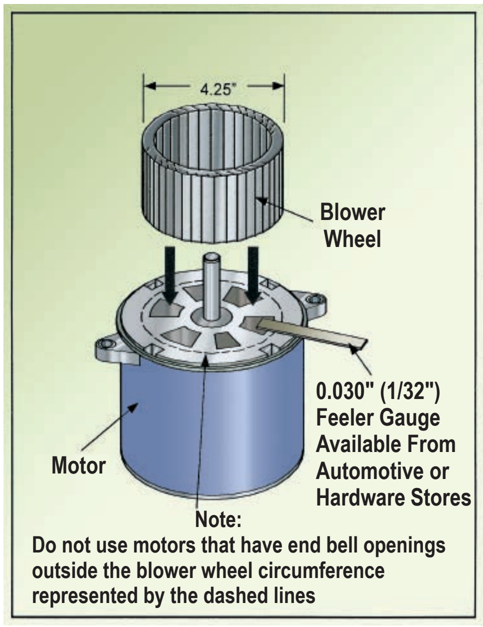

Use of a motor with cooling openings that are not covered will cause a loss of static pressure at the burner retention head due to air leakage and turbulence. Use a thickness feeler gauge to measure the gap between the motor and the blower wheel. Place the gauge on top of the motor and bottom of the blower wheel. The setscrew must be centered on the flat of the motor shaft before it is tightened.

Burner couplings

A flexible burner coupling is a mechanical device used to connect two rotating shafts. It permits a small amount of misalignment between shafts. The best coupling to use is the one made by the burner manufacturer.

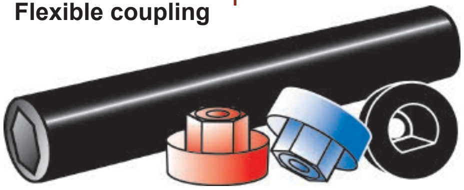

Figure 11-12: Flexible coupling

For obsolete burners, or burners that require couplings that are not available, many technicians carry a coupling kit to make various size couplings to fit most burners, Figure 11-12. These couplings are made up of two plastic ends and a center piece that is cut to size. The molded ends are designed to slip over the motor and pump shafts.

To install, follow the manufacturer's instructions and pay particular attention to the length of the coupling. If the center piece is too long, when the motor and the pump are bolted in place, the pressure may put an undue strain on the motor and may keep it from starting.

Warm air furnace motors and fans/blowers

Another common use of motors in our industry is to move air through ductwork.

Four types of blower motors can be found on warm air systems:

1. The split phase, fractional horsepower motor used for belt driven blowers.
2. The capacitor start motor, also used for belt drive.
3. The multi-speed, direct drive PSC motor/blower assembly. These blowers are ideal for use in systems that also provide air conditioning because they can run at a slower speed for heating and faster speed for air conditioning.
4. Electronically Commutated Motors (ECMs), See Fig 11-13, have grown in popularity due to their low power consumption, infinite motor speed capability and reliability. The ECM has all the efficiency and speed control advantages of a DC motor

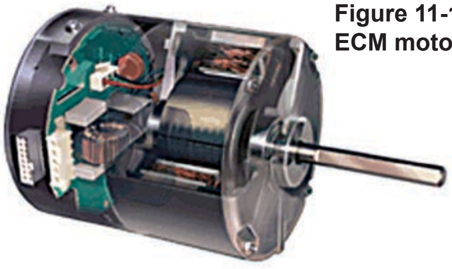

Figure 11-13: ECM motor

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with none of the disadvantages, such as carbon brush wear, short life and noise. The ECM uses single phase AC input power and converts it into three phase DC for operation. ECM motors offer superior efficiency and reduced noise.

ECM motors have two main components, the motor and the microprocessor-based control module. Furnace manufacturers' troubleshooting and replacement recommendations should always be followed when servicing ECM motors. ECM control modules are factory programmed for specific manufacturer applications. If you use the wrong control module, it may result in improper or no blower operation.

Belt driven blowers

These are the most common type blowers on older furnaces. These motors are mounted to the blower and drive it through pulleys and a "V" belt. Adjusting the size of the pulleys changes the speed of the blower. The larger the pulley on the motor, the faster the fan will turn. The larger the pulley on the fan, the slower the fan will turn.

Variable pitch pulleys can be adjusted to increase or decrease size to change the speed without changing the pulley. When adjusting the speed of this type of motor, it is imperative to take an amp reading to be sure that the increase in speed does not work the motor beyond its rated capacity.

Figure 11-14 shows some of the wide variety of pulleys available. Note how the adjustable pulley opens and closes to vary diameter. Being too far open or closed will cause poor seating of the V belt. Figure 11-15 stresses the importance of using the right size belt for the pulley being used. The width of belts and pulleys varies, so be sure that both are the same width when changing a belt and/or pulley. Proper tension on belts without over-tightening is important.

Figure 11-14

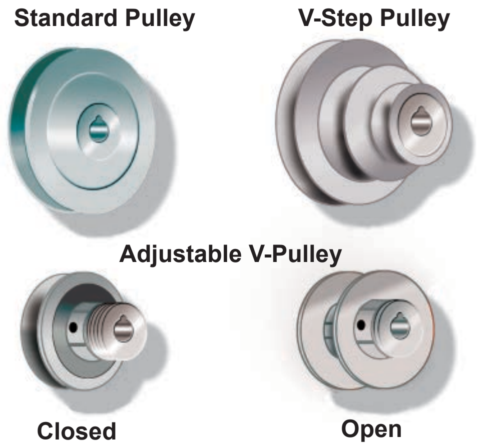
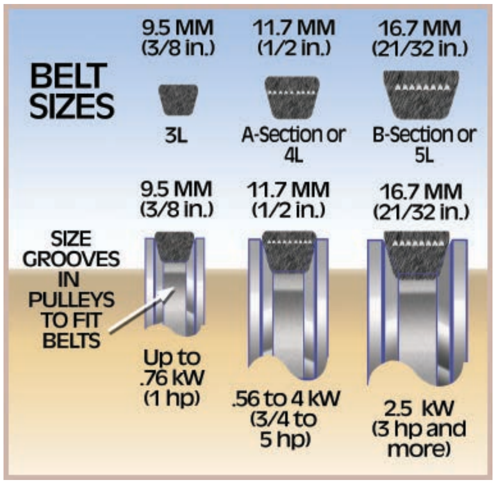


Figure 11-15: Pulley belts



Direct drive blowers

These are blowers with the motor mounted inside the wheel of the blower with the shaft of the blower connected directly to the blower wheel. Some of these are multi-speed PSC motors. In this case, speed is adjusted by swapping the wires as indicated on the wiring diagram on the blower.

On both belt driven and direct drive blowers, it is important that the blower, Figure 11-16, is clean and in good repair. Dirty blowers can restrict airflow. Broken or bent blades can cause vibration, as the blower will be out of balance.

Figure 11-16: Motor blower

Circulator motors

Hot water heating systems rely on circu-

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lator pumps to move the hot water through the heating system. There are two kinds: cartridge and 3-piece circulators. With cartridge units, the pump impeller is fastened directly to the motor shaft as shown in Figure 11-17.

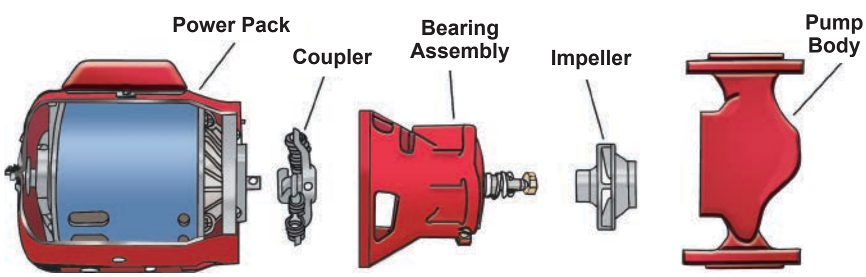
Figure 11-17: Cartridge circulator

Three-piece circulators feature a bearing assembly that connects the motor to the pump body. The bearing assembly shaft is connected to the motor shaft by a pump coupling. The pump impeller is fastened to the bearing assembly shaft. Figure 11-18 shows a 3-piece circulator.

Circulator couplings

These are used on three-piece circulators to connect the motor to the bearing assembly, just as a burner coupling connects the burner motor to the fuel unit. Figure 11-18.

Figure 11-18: Three-piece circulator



Couplings can wear and break. Age and/or excessive oiling of the circulator can cause the rubber mounts on the motor to sag causing the motor to become misaligned with the bearing assembly. As the mounts continue to sag, the misalignment worsens and the coupling breaks. It's important to check motor mounts when replacing the coupling and replace them as necessary. Figure 11-19.

Figure 11-19: Broken Coupling

On some 3-piece circulators, the coupling has tension pulling the shaft toward the motor with a spring. This holds pressure on the water seal in the bearing assembly. Care should be taken to maintain this pressure during the change, or water will leak out around the circulator shaft.

Chapter 11: Additional Resources

NORA has compiled a library of additional technical resources for your continued education. Scan the QR code or go the the web address. Check back often as NORA will contnually add content as it becomes available.

You will find:

- Videos
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