Chapter 10
MOTORS, FANS & RELAYS

IN THIS CHAPTER
• Motor components
• How motors work
• The types of motors used in heating systems
• Diagnosing motor problems
Chapter 10

Motors

Introduction

Electric motors run the fuel unit, run the fan, providing combustion air to the fire, run the circulating pumps in a hot water system, and power the blowers in forced warm air and air conditioning systems. In addition, low voltage motors open and close zone valves and damper motors.

Motor components

Residential and commercial oilburner motors are generally AC motors. DC motors are sometimes used in some specialty applications, such as power washers and road maintenance equipment. Most motors use AC split-phase induction motors equipped with two sets of windings. This type generally has low to moderate starting torque with high amp draw on start-up.

There are basic components of a motor:

- **Base**: the device used to support the motor.
- **Rotor**: The permanent magnets or windings attached to the motor shaft that follow the rotating magnetic field created by the electromagnets in the *stator* and cause the rotation of the motor shaft.
- **Stator**: The stator contains stationary electromagnets and windings that create the field that causes the motor to turn. The start and run windings are wound around the stator. When electricity flows through these windings, it creates the magnetic field.
- **Start windings**: Electric current flowing in these windings provides the extra power needed to start the rotor turning and are turned off when the motor is up to full

Figure 10-1: Cutaway of burner motor
Starting windings will draw high current (amps) during the starting phase for a split phase motor.

**Run windings:** Electric current flow in these windings creates the rotating magnetic field in the stator. This maintains the shaft rotation after the start windings have been disconnected. The starting and running windings are oriented perpendicularly to each other. The windings are designed so that the current in one lags the current in the other. The difference makes the resulting magnetic field rotate, creating a torque that turns the motor shaft.

**Start switch:** Start windings draw many amps. On split-phase motors, we turn off the power to these windings once the motor has started to turn in order to conserve electricity. The centrifugally operated switch used in split-phase and capacitor start motors opens and disconnects the start winding after the motor reaches 75% to 80% of full speed. The power remains connected to the run windings. The centrifugal switch throw-out speed for a 3,450 RPM burner motor is about 2,800 RPM.

The flange end of the motor is sized to bolt onto the oilburner casting. Although most burner manufacturers use the same size flange mount, you may encounter some that are different. Generally, the 3,450 rpm flame retention burner motor has a smaller M flange with a circumference of 6¾". The N flange that can be found on older burners and small commercial motors measures 7¼".

Motors are typically rated by voltage, amp draw, direction of rotation, frame size, and horsepower. The motor rating plate provides this information. The frame sizes are established by NEMA (National Electrical Manufacturers Association). Some motors have cooling holes in the motor ends called bells, but some bells are totally closed. 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 for a burner. Shaft bells with fewer air holes will generally provide higher pressure. A reduction in pressure and flow can negatively impact burner operating characteristics.

Not all manufacturers refer to rotation in the same manner. Some manufacturers consider rotation when looking at the shaft bell, others by looking from the end bell towards the shaft. Be aware of this when ordering a new motor or when installing a replacement motor that needs to be wired to establish rotation.

**Motor oiling**

There are two ways motors are lubricated:

1. **Permanently lubricated**—this type of motor does not have any oiling ports and should not be oiled.
2. Motors that require lubrication are oiled according to their duty cycle using SAE 20 oil.

   - **Occasional Duty**—less than 2 hours a day: Oil every 5 years.
   - **Intermittent Duty**—run 2 to 12 hours a day: Oil every 2 years.
   - **Continuous Duty**—12 or more hours a day: Oil once every year.

   *Most oilburner motors see intermittent duty.*
Chapter 10—Motors

Start switch
The start switch of a motor is wired internally in series with the start winding. There are two parts to the start mechanism—the stationary switch, with its contacts—and a governor. The governor holds the switch contacts together when the motor is not running and releases the pressure to open the contacts when the motor is up to speed. This action must occur quickly; if not, the start winding can be damaged. The starting switch is a centrifugal switch. Its contacts are weighted and a spring holds them closed. As the motor shaft begins to turn, centrifugal force pushes the weights against the spring, opening the contacts of the switch. Figure 10-2 is a drawing of the centrifugal start switch.

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. A motor may not turn because of bad bearings, bound up fuel pump, or any other reason for the rotor to be “locked in” place.

Motor wiring
Figure 10-3 shows the internal schematic of the split phase fractional horsepower motor pictured in Figure 10-1. It is used in most residential burners. Note the location of the start switch. Apart from the size and voltage shown on the motor nameplate, there is also a frame number. This refers to the type of cradle or mounting the motor has.

Capacitor start motors
We use capacitors to build up an electric charge and store it until it is needed. A capacitor is made of two conducting plates separated by an insulator. A capacitor start motor has a starting capacitor inserted in series with the start switch and starting winding, creating a circuit which is capable of a much greater phase shift (and so, a

Figure 10-3: Split phase motor, internal wiring
Figure 10-4: Capacitor start split phase motor

much greater starting torque). Figure 10-4 shows the internal connections of a split phase motor with a start switch and also a start capacitor in the line to the start winding. Many circulator and commercial oilburner motors are capacitor start motors.

**Thermal or motor overload switch**

The thermal or overload switch is wired in series with the motor windings and is activated (opens) when an unusual increase in temperature occurs inside the motor. This switch protects the motor from being damaged by overheating. If the motor overheats, the bimetal in the switch will warp then the switch will open and turn off the motor. There are two types used in oilburner motors:

1. **Manual reset thermal protectors** are most common and must be reset by pressing a reset button. Figure 10-5 shows the operation of a manual reset overload.

2. **Automatic reset**; this type will reset itself (close) after the motor cools down.

Figure 10-6 shows the action of an automatic reset overload. In Figure 10-7, a schematic wiring diagram shows the location of the overload switch in the circuit.

When the thermal overload switch shuts the motor off, it indicates motor overheating. This is caused from 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 oil pump has seized due to rust or debris in the gear set.

3. The motor bearings are bad.

4. The return is plugged.

5. There is misalignment of motor to pump—check to see if any mounting bolts have loosened, causing improper seating of the motor or pump to the burner housing. Also, check to see if the pump coupling is too long, causing pressure on the motor shaft.

6. The start switch is dirty or broken. This prevents electricity from flowing to the starting windings. With this switch open, current will still flow to the run winding, but the motor will not start. The increased amperage will generate heat in the line and cause the overload switch to trip out.

7. The centrifugal start switch has failed to disconnect the start windings from the AC power when the motor has reached approximately full speed; the motor will overheat.

8. The fan or blower wheel is jammed or very dirty.

9. The motor is in a very hot environment (the inside of a hot vestibule of a furnace).

10. There is dirt in the motor cooling vents; this will also cause the motor to overheat.

11. 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 10-8) to make sure the motor current does not exceed 10% over the motor nameplate current.

**Wiring connections and reversing rotation**

Some oilburner motors have an “S” cord attached to the motor and connected to a junction box. If this is the case, be certain the BX cable or conduit to the junction box is tightly fastened to provide a good bonding to ground. If Romex cable is used, be certain the bonding wire is fastened to the junction box.

The motor rotation on some oilburner and blower motors can be electrically reversed. The instructions may be found on the nameplate of the motor or inside the cover that provides access to the wiring connections.

The rotation of a motor is determined by the direction of the current to the start winding. If we reverse the connections to the start winding we can reverse the rotation of the motor. The instructions with each motor will identify these connections and how to change them. Figure 10-9 shows how to switch the wires to reverse rotation.
Figure 10-9: Reversing rotation of burner motor wires

Figure 10-10: Bearings

Excessive oil can also be a problem. Follow the recommended lubrication procedure.

Figure 10-10 illustrates the types of bearings. **Ball bearings** consist of a ring of steel balls held in place around the rotor. As the rotor turns, the balls are free to roll, aided by lubricating grease. Because the rotor is attached to the inside ring of the ball bearing assembly, there is no end play (the fan wheel is not free to move away from the motor flange). The gap between the fan wheel and the housing is kept constant, minimizing air leakage and increasing the zero-flow static pressure by as much as .3 to .4 inches of water column, compared to sleeve bearing motors.

**Bearings**

There are two basic types of bearings used on most of the motors in our industry: they are sleeve type and ball bearing type.

**Sleeve bearings**, also called *bushings* or *self-aligned bearings*, are special metal sleeves around the rotor shaft. Oil is applied between the shaft and the sleeve; the thin film of oil lubricates the shaft and allows it to turn with little friction. Many modern sleeve bearings are permanently self-lubricating and have a sponge like material that continually supplies oil as the rotor turns. Sleeve bearings require increased starting torque if they are contaminated by rust or dirt. Worn, dry, or tight bearings will cause motor overload and possible thermal overload lockout.
PSC (Permanent Split Capacitor) motors

Most new oil burners feature PSC motors. A PSC motor uses a capacitor (a device that stores and releases an electrical charge) in one of the windings to increase the current lag between the two windings. Unlike conventional capacitor start motors, PSC motors have no centrifugal starting switch and the second winding is permanently connected to the power source. Both the capacitor (auxiliary) winding, and the main winding remain in the circuit the entire time the motor is running—hence the name “permanent.” PSC Motors perform with better efficiency, offer equal or increased power output and lower starting and running current than conventional split phase motors.

See Figures 10-11 and Table 10-1.

Table 10-1: Heating system motor testing chart (courtesy Beckett Corp.)

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

1 Most standard oil 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%).
Diagnosing motor troubles

Typical heating system motors are reliable, but problems can occur. The following should help you quickly pinpoint a problem. For more details, see Chart on page 10-16.

Motor Trouble Check List

1. The motor will not start
   a. Is voltage present at the motor? Is it the correct voltage? (It must be within 10% of nameplate.) Are all wiring connections tight?
   b. Is the motor off due to overload? If manual reset, push the button. If auto, wait for the motor to cool until it resets.
   c. Is the capacitor (if needed) functioning? If in doubt, replace it with a capacitor of the same rating.
   d. Is the load on the motor excessive? If the motor starts after the load is removed, this could be the problem.
   e. Are the bearings on the motor seized or dry? If so, free up and lubricate.

2. Noises
   a. Is motor lubricated? If not, do so, unless it is permanently lubricated.
   b. Is the alignment of the motor shaft and the driven device correct?
   c. On a belted unit, is the belt OK? Is it too tight or too loose? The belt should have a 1" play.
   d. Noise could be caused by shaft end-play (the distance the shaft will move in and out of the motor). A new motor will have no more than .035" of movement. If the shaft end play is more than .060", the motor could be suspect.

3. Motor overheats
   a. Is there adequate ventilation? Are the air venting slots on the motor clean and unobstructed?
   b. Is the load excessive? Use an ammeter to measure the current draw. If the load or the draw is more than the nameplate rating, the load must be either reduced or a larger more powerful motor must be installed. Make sure that the driven device is unrestricted in its operation.

   NOTE: When checking the current draw of the motor, the service factors must be considered. A motor with an amp rating of 4.0 and a service factor of 1.25 can safely be operated at 5 amps.
   c. Is the motor located in an excessively hot area?
PSC motors are also frequently used in air handlers, fans, and blowers and other cases where a variable speed is desired. By changing taps on the running winding, but keeping the load constant, the motor can be made to run at different speeds.

**Troubleshooting ‘dead spots’**

‘Dead spot’ is a common term for a certain orientation of the rotor at which the motor will not start. Two things can cause dead spots. First, there could be a fault in the manufacturing process. If so, the motor may not have enough torque to start the burner. This condition is rare and cannot be repaired. Second, if the start switch of a split phase motor is unevenly worn or has shifted out of position, the contacts may become slightly separated when the rotor is in a particular location. No current will flow through the starting winding and the motor will not start. If this is the problem, the motor should be replaced.

**Troubleshooting the start switch**

To check a faulty start switch, you need an ohmmeter. The motor starting windings have a much lower resistance than the run windings do. Use this difference to determine if the start switch is defective. When the start switch is functioning properly, both the start and run windings are connected, resulting in lower resistance. If the start switch is faulty, the start windings will not be connected or will intermittently be connected. This results in higher resistance or fluctuating resistance as the motor shaft is rotated.

Set the scale on your ohmmeter at its lowest setting and zero out the meter by touching the test leads together and adjusting the meter to show zero ohms. Turn off the power, disconnect the motor input leads and remove the motor from the housing. Place the motor on its back, shaft up. Connect your meter across the black and white motor input leads. If the start switch is functioning properly, the resistance should be about 2 to 4 ohms. If the resistance is much higher (in the range of 7 to 10 ohms) then the start switch is probably bad.

To double-check the measurement, pull up on the shaft and note if the resistance drops to the proper 2-4 ohms. If it does, the switch is definitely bad and the motor should be replaced.

The most important function of this test is to make sure the resistance across the motor leads does not change when the motor shaft is pushed down or rotated in a full circle. Rotate the shaft slowly and note the resistance. If it goes up to 7-10 ohms at any point in the rotation, you have found your dead spot. If it is the kind of motor where you can see the start switch, push down on the switch and the resistance should increase from 2-4 to 7-10 ohms.

**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 (Figure 10-12) with a capacitance range. On page 10-17, from RW Beckett, is a PSC motor troubleshooting checklist.

**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 8-21 and Figure 8-25.

Caution: Capacitor discharge 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 charges the capacitor slightly in order to make a resistance measurement, if you desire to repeat the measurement, discharge the capacitor first (step 2).*

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 (see Figure 10-13), than a digital meter. With a digital meter, the resistance reading should gradually increase to infinite resistance (either quickly or slowly, depending on the meter).

5. Using the capacitance function of the multimeter, see Figure 10-14, and after shorting the capacitor, determine the microfarad output of the capacitor. The reading should be between 5-10% of the rating.

**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 L1 motor power lead and the other meter lead to each of the capacitor leads, one at a time. See Figure 10-15.

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 15-25 ohms. If you do not observe these resistances, the motor windings are faulty, and the motor should be replaced.

**Miscellaneous things to look for:**

- Make sure bearings are in good condition and oiled.
- Check and be sure there is no excessive end play on the shaft. This can cause noise and hard starting.
- Is all the wiring in good condition? If not, replace and secure with appropriate connectors.
- On blower motors check belt size, width, and tension. Remember, overtightening is as bad as a loose belt.
• Make sure the motor is aligned with the driven device and the coupling is tightened.
• Make sure the motor is operating within the proper amp ratings.
• Make sure voltage and rotation are 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 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, or at least long enough and the proper diameter to securely couple to the driven device. Bushings are sometimes used to increase the diameter of the shaft.
7. Rated amperage must be at least as high as the driven device will require.

Replacing an oilburner motor
The specified motors for most oilburners either are the closed-end type or models with small cooling openings in the shaft bell at the motor shaft end. The small openings are satisfactory as long as they are covered once 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 10-16.

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. Then tighten the setscrew.

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 “Nylo-Flex™” coupling, see Figure 10-17, fits most burners, thereby reducing truck inventory. 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 and do not require setscrews. They can be purchased with a variety of ends to match the various pump shaft sizes.

With this type of coupling, it is important to slide the ends on the shaft to the end of the flat portion or the coupling will move. Measure the length needed for the center piece and cut it exactly to that measurement. The center piece is hollow and will slide over any portion of the shaft extending beyond the end piece. Be sure the motor and the pump...
are mounted tight to the burner housing before measuring the center piece. If you cut the center piece 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**

The third most common use of motors in our industry is for moving air through warm air and air conditioning ducts. Many are multi-speed motors that can be operated at any of two or more speeds. In the case of multi-speed PSC motors, the speed is dependent on the load.

Three 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 motor/blower assembly. These blowers are often used on systems that also provide air conditioning. They can run at a slower speed for heating and faster speed for the air conditioning. These motors can be either PSC type motors or a newer design called an ECM, see Figure 10-18.

The ECM is a DC voltage motor. ECM stands for Electrically Commutated Motor. ECMS 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 with none of the disadvantages, such as carbon brush wear, short life, and noise. The ECM uses 1-phase AC input power and converts it into 3-phase operation. Three-phase motors offer superior efficiency and reduced noise.

**Belt driven blowers**

These are the most common type blowers on older oil-fired 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 10-19 shows some of the wide variety of pulleys available. Note how the adjustable pulley opens and closes to vary diameter. Make sure it is not too far open or closed causing poor seating of the V belt. Figure 10-20 stresses the importance of using the right size belt for the pulley being used. Width of belts and pulleys varies so be sure both are the same when changing motor and pulley. Proper tension on belts without over-tightening is important.
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 types of blowers, it is important that the blower, Figure 10-21, is clean and in good repair. Dirty, bent or broken blades on the blower can cause excessive amperage draw due to increased load. Broken or bent blades can cause vibration, as the blower will be out of balance.

Circulator motors

Hot water heating systems rely on circulator pumps to move the hot water through the heating system. There are two kinds: cartridge and three-piece circulators. With cartridge units, the pump impeller is fastened directly to the motor shaft as shown in Figure 10-22.

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 10-23 shows a three-piece circulator. Circulator motors often are PSC motors, as shown on page 10-9.

Circulator couplings

These are used on three-piece circulators to couple the motor to the circulator pump. See Figure 10-23. These can wear and break.

Excessive oiling of the circulator can cause the rubber motor mounts to sag, causing the coupling to break; therefore check motor mounts when replacing the coupling. The motor mounts need to be replaced if they have softened.

On some of these circulators, the coupling has tension pulling the shaft toward the motor with a spring. This holds pressure on the water seal in the circulator. Care should be taken to maintain this pressure during the change, or water will leak out around the circulator shaft. It is best to reduce the water pressure on the boiler while changing this type.
<table>
<thead>
<tr>
<th>Trouble</th>
<th>Cause</th>
<th>What To Do</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Motor fails to start</strong></td>
<td>Blown fuses</td>
<td>Replace with time-delay fuses. Check for grounded winding.</td>
</tr>
<tr>
<td></td>
<td>Low voltage</td>
<td>Check for inadequate wiring or extension cords. Check for low system voltage. Call electric company.</td>
</tr>
<tr>
<td></td>
<td>Improper line connections</td>
<td>Check connections against diagram supplied with motor.</td>
</tr>
<tr>
<td></td>
<td>Overload (thermal protector) tripped</td>
<td>Check and reset overload relay in starter. Check heater rating against motor nameplate current rating. Check motor load. If motor has manual reset thermal protector, check if tripped.</td>
</tr>
<tr>
<td></td>
<td>If three-phase, one phase may be open</td>
<td>Indicated by humming sound. Check lines for open phase. Check voltage with motor disconnected, one fuse blown</td>
</tr>
<tr>
<td></td>
<td>Defective motor or starter</td>
<td>Repair or replace</td>
</tr>
<tr>
<td><strong>Motor stalls</strong></td>
<td>Overloaded motor</td>
<td>Reduce load or increase motor size.</td>
</tr>
<tr>
<td></td>
<td>Low motor voltage</td>
<td>See that nameplate voltage is maintained.</td>
</tr>
<tr>
<td><strong>Motor does not come up to speed</strong></td>
<td>Not applied properly</td>
<td>Consult motor service firm for proper type. Use larger motor.</td>
</tr>
<tr>
<td></td>
<td>Voltage is too low at motor terminal due to line drop</td>
<td>Use higher voltage tap on transformer terminals, increase wire size. Check for poor connections. Voltage unbalance.</td>
</tr>
<tr>
<td></td>
<td>Starting load too high</td>
<td>Check load motor is carrying at start.</td>
</tr>
<tr>
<td><strong>Motor takes too long to accelerate</strong></td>
<td>Excess loading; tight belts. High inertia load</td>
<td>Reduce load; increase motor size. Adjust belts.</td>
</tr>
<tr>
<td></td>
<td>Inadequate wiring</td>
<td>Increase wire size. Check for poor connections.</td>
</tr>
<tr>
<td></td>
<td>Applied voltage too low</td>
<td>Reconnect to a higher tap. Increase wire size. Check for poor connections.</td>
</tr>
<tr>
<td></td>
<td>Defective motor</td>
<td>Repair or replace.</td>
</tr>
<tr>
<td></td>
<td>Inadequate starting torque</td>
<td>Replace with larger motor.</td>
</tr>
<tr>
<td><strong>Motor vibrates or is excessively noisy</strong></td>
<td>Motor is misaligned</td>
<td>Realign</td>
</tr>
<tr>
<td></td>
<td>Three-phase motor running single phase</td>
<td>Check for open circuit, blown fuses or unbalanced voltages.</td>
</tr>
<tr>
<td></td>
<td>High or unbalanced voltages</td>
<td>Check wiring connections, transformer.</td>
</tr>
<tr>
<td></td>
<td>Worn, damaged, dirty or overloaded bearings</td>
<td>Replace; check loading and alignment.</td>
</tr>
<tr>
<td></td>
<td>Loose sheave or coupling</td>
<td>Tighten set screw(s); replace.</td>
</tr>
</tbody>
</table>

Is the motor off on overload? If manual reset, push the button. If auto, reset and wait for or assist the motor to cool until it resets.
Is the capacitor (if needed) OK? The simplest way to test the capacitor is to replace it with one of the same rating.
Is the load on the motor excessive? If the motor starts after the load is removed, this could be the problem.
Are the bearings on the motor seized or dry? If so, free up and lubricate.
### PSC Motor Troubleshooting

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cause</th>
<th>Recommended Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor does not start</td>
<td>No power to motor</td>
<td>Check wiring and power from primary control lead. If necessary, replace control, limit controller or fuses (time-delay type).</td>
</tr>
<tr>
<td></td>
<td>Insufficient voltage supply</td>
<td>Check power from primary control.</td>
</tr>
<tr>
<td></td>
<td>Thermal protector has tripped</td>
<td>Determine and repair cause of thermal overload and reset (if manual re-settable).</td>
</tr>
<tr>
<td></td>
<td>Pump shaft will not turn</td>
<td>Disconnect motor from pump. Turn coupling to ensure free rotation of pump shaft.</td>
</tr>
<tr>
<td></td>
<td>Capacitor or windings have failed</td>
<td>Check capacitor and windings.</td>
</tr>
<tr>
<td></td>
<td>Motor bearings have failed</td>
<td>Turn the motor shaft, which should turn easily.</td>
</tr>
<tr>
<td>Motor starts, but does not reach full speed</td>
<td>Motor is overloaded</td>
<td>Disconnect pump from motor. Turn pump shaft to ensure free rotation.</td>
</tr>
<tr>
<td></td>
<td>Insufficient voltage supply</td>
<td>Check power from primary control. Voltage should be 110V - 120V.</td>
</tr>
<tr>
<td></td>
<td>Capacitor or windings have failed</td>
<td>Check capacitor and windings.</td>
</tr>
<tr>
<td>Motor vibrates or is noisy</td>
<td>Bearings are worn, damaged or fouled with dirt or rust</td>
<td>Replace motor.</td>
</tr>
<tr>
<td></td>
<td>Motor and pump are mis-aligned with each other or housing</td>
<td>Check pump to motor, motor to housing, and pump to housing alignment.</td>
</tr>
<tr>
<td></td>
<td>Blower wheel or wheel balancing weight (if applicable) is loose</td>
<td>Check blower wheel and balancing weight (if applicable) for location and tightness.</td>
</tr>
<tr>
<td>Motor draws excessive</td>
<td>Motor and pump misaligned with each other or housing</td>
<td>Check pump to motor, motor to housing, and pump to housing alignment.</td>
</tr>
<tr>
<td></td>
<td>Motor is undersized for the application</td>
<td>Increase motor size if needed.</td>
</tr>
<tr>
<td></td>
<td>Motor windings are damaged</td>
<td>Check windings. If damaged, replace motor.</td>
</tr>
</tbody>
</table>

**Checking the PSC Motor windings:**

1. Remove power from the burner, and detach the motor power leads from the burner.
2. Disconnect the two leads from the capacitor terminals.
3. Connect one Ohmmeter lead to the L1 motor power lead and the other meter lead to each of the capacitor leads, one at a time. See Figure 10-15.
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.