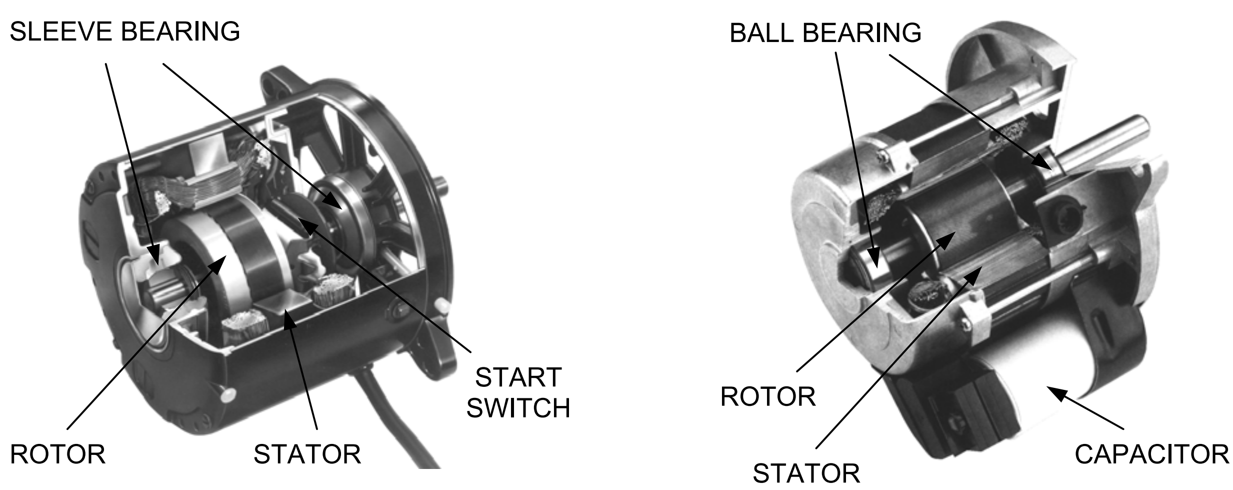
AN INTRODUCTION TO PSC MOTORS

In March of 1993, Beckett released a technical bulletin entitled, “Burner Motor Service Facts” (Beckett Part #664828), which addressed basic operation and service of the split phase motor used on the Model AF and AFG oil burners. As a companion to that bulletin, this bulletin will discuss operation and troubleshooting of the permanent split capacitor (PSC) motor now available for AF and AFG burners. Also, common motor construction considerations will be discussed to help you wisely evaluate motors.

SPLIT PHASE AND PSC MOTOR TECHNOLOGY

Each residential oil burner motor has two windings, oriented perpendicular to each other. The windings are designed so that the current in one lags the current in the other. This difference makes the resulting magnetic field rotate, creating a torque that turns the motor shaft.

FIGURE 1: SPLIT PHASE AND PSC MOTOR CONSTRUCTION



SPLIT PHASE MOTOR **PSC MOTOR**

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After a **split phase** motor is started, a centrifugal switch on the shaft opens, disconnecting the start winding. The motor then runs using only the run winding. See the simplified circuit diagram on the following page.

A **PSC** motor uses a capacitor (a device that can store and release electrical charge) in one of the windings to increase the current lag between the two windings. Both the capacitor (auxiliary) winding and the main winding remain in the circuit the entire time the motor is running, hence the name “permanent”.

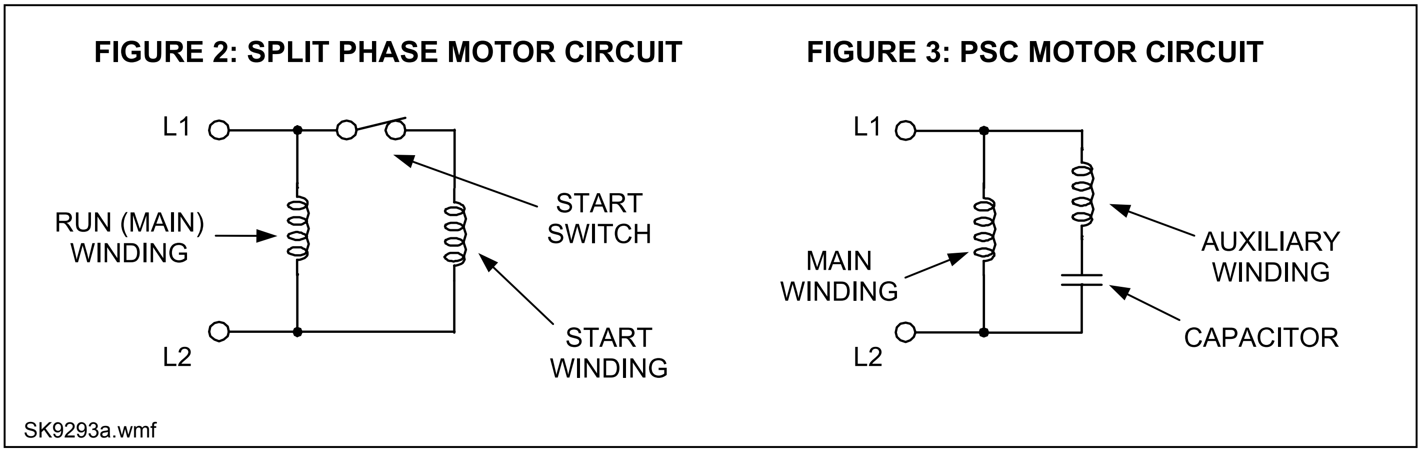


TABLE 1: BECKETT TEST DATA - 1/7 HP AFG SPLIT PHASE AND PSC MOTORS

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 rpm [2]	PSC: Similar or increased output power.

[1] Most standard mini 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%).

The **PSC** motors tested above perform with increased efficiency, equal or increased power output, and lower starting and running current than the split phase motors.

MOTOR CONSTRUCTION: FLANGES

The AFG burner motor's mounting flange is commonly called a 48M flange. "48M" is a NEMA (National Electrical Manufacturers Association) code for this style of motor mounting, **enabling any motor with this designation to be mounted to any other 48M motor burner.** 48N is the NEMA code for the larger mounting flange (for instance, for Beckett "S" chassis burners). Some motors have cooling holes in the flange, and some flanges are totally closed. If the blower wheel does not cover the cooling holes when the wheel is installed, too much air can leak through the holes, decreasing the static pressure and possibly affecting burner performance. For more information, see the August 1998 Beckett technical bulletin entitled, "Common Service Questions Asked About the AFG Oil Burner" (Part #664844).

MOTOR CONSTRUCTION: THERMAL PROTECTORS

Most UL approved oil burner motors have an internal thermal protector that turns off the burner if the motor draws excessive current. Many of these can only be reset manually (by pushing the reset button on the motor's exterior). Some motor protectors do not require a manual reset, but reset automatically after the motor has cooled down. **Note:** Applications in which the ambient temperature exceeds the labeled ambient rating of the motor may cause the protector to trip erroneously.

MOTOR CONSTRUCTION: BEARINGS

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, lubricating the shaft and allowing it to turn with little friction due to the thin film of oil (similar to skating on a thin film of water while ice skating). Many modern sleeve bearings are permanently self-lubricated and have a sponge-like material which continually supplies oil as the rotor turns. Sleeve bearings require increased starting torque if they are contaminated by rust or dirt, since the rotor must spin at high speed in order to distribute the lubricating oil properly.

Ball bearings consist of a ring of steel balls held in place around the rotor. The balls are free to roll as the rotor turns, aided by lubricating grease. Because the rotor is attached to the inside ring of the ball bearing assembly, there is no end play (the blower wheel is not free to move away from the motor flange). The gap between the blower wheel and the housing is kept constant, minimizing air leakage and increasing the zero-flow static pressure as much as 0.3 to 0.4 inches water column compared to sleeve bearing motors.

TROUBLESHOOTING PSC MOTORS

PSC motors have two major areas to troubleshoot: ① the capacitor and ② the windings. Both are relatively simple to check and require only an Ohmmeter.

CHECKING CAPACITORS. A failed capacitor will cause a PSC motor to either stop or run more slowly than designed, and 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. Holding a screwdriver by its insulated handle, momentarily place the blade across the capacitor terminals to ensure that the capacitor is fully discharged**. CAUTION: Capacitor discharge can cause physical harm.**
3. Observe the Ohmmeter 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).

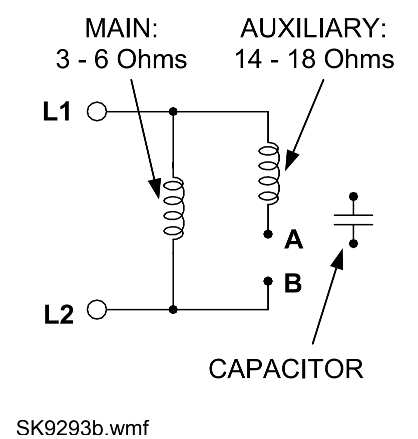
The Ohmmeter reading should jump immediately to a non-infinite resistance value, and then quickly increase again to infinity. This should happen in a fraction of a second, since the capacitor will charge quickly and then resist any more charge. If the meter settles at zero Ohms, the capacitor has short circuited. If the meter resistance is infinite the entire time, the capacitor has open circuited. A failed capacitor (open *or* short circuited) should be replaced by a capacitor with the same capacitance (microFarads or µF) and a voltage rating at least as great as the original one. **Test Tip**: The quick capacitor response is more easily observed with an analog "needle" meter, rather than a digital meter.

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 (point A or B – you may not be able to tell which is which).
4. Record the two resistance values.
5. Repeat by measuring between the other motor power lead (L2) and each of the capacitor leads, one at a time.

For the Beckett PSC motor, from L1 you should have measured 3-6 Ohms and 14-18 Ohms. From L2 you should have measured a short (<1 Ohm) and 17-24 Ohms. If you do not observe these resistances, the motor windings are faulty, and the motor should be replaced.

FIGURE 4: PSC CIRCUIT



TROUBLESHOOTING "DEAD SPOTS"

"Dead spot" is a common term for a certain orientation of the rotor at which the motor (PSC *or* split phase) will not start. Dead spots can be caused by two things. First, there could be a break in one of the aluminum bars inside the rotor, due to a fault in the molding process. If this occurs and the rotor happens to be in that particular spot when the motor is turned on, the motor may not have enough torque to start the burner. This fault in the rotor is quite rare, and cannot be repaired. Secondly, if the start switch of a split phase motor is unevenly worn, the contacts may become slightly separated if the rotor is in a particular location. No current will be able to flow through the start winding, inhibiting the motor from being able to start. For more information on troubleshooting the start switch, see the Beckett March 1993 technical bulletin (Part #664828).

PSC MOTOR TROUBLESHOOTING		
CONDITION	**CAUSE**	**RECOMMENDED ACTION**
Motor does not start.	No power to motor.	Check wiring and power from primary control lead. If necessary, replace control, limit controller, or fuses (time-delay type).
	Insufficient voltage supply.	Check power from primary control.
	Thermal protector has tripped.	Determine and repair cause of thermal overload and reset (if manually resettable).
	Pump shaft will not turn.	Disconnect motor from pump. Turn coupling to ensure free rotation of pump shaft.
	Capacitor or windings have failed.	Check capacitor and windings (see page 3).
	Motor bearings have failed.	Turn the motor shaft, which should turn easily.
Motor starts but does not reach full speed.	Motor is overloaded.	Disconnect pump from motor. Turn pump shaft to ensure free rotation.
	Insufficient voltage supply.	Check power from primary control. Voltage should be 110 V – 120 V.
	Capacitor or windings have failed.	Check capacitor and windings (see page 3).
Motor vibrates or is noisy.	Bearings are worn, damaged, or fouled with dirt or rust.	Replace motor.
	Motor and pump are misaligned with each other or housing.	Check pump to motor, motor to housing, and pump to housing alignment.
	Blower wheel or wheel balancing weight (if applicable) is loose.	Check blower wheel and balancing weight (if applicable) for location and tightness.
Motor draws excessive current (>10% over rated current).	Motor and pump misaligned with each other or housing.	Check pump to motor, motor to housing, and pump to housing alignment.
	Motor is undersized for the application.	See Table 1, note 1. Increase motor size if necessary.
	Motor windings are damaged.	Check windings. If damaged, replace motor.