Tips For Troubleshooting Electric Motors

Understanding the nuances of various motor types is essential when servicing or installing such units

By Dennis Bush

After more than 100 years of use, with an ever increasing installed base, there are probably few aspects of an electric motor's usage and failure modes that have not been documented.

This article is best viewed as a starting point for motor troubleshooting. It is by no means complete, though much of the material comes from the Motor Mastery University. For additional information that could prove useful, check with motor manufacturers, equipment manufacturers, groups such as the Refrigeration Service Engineers Society (RSES), the National Electrical Manufacturers Association (NEMA), the Electrical Apparatus Service Association (EASA), and testing agencies. The challenge for the service technician is to

One approach is to maintain a library of reference materials along with a formalized troubleshooting procedure for on-the-job use. Troubleshooting involves three main elements:

1. General motor knowledge coupled with specific application knowledge.

2. The troubleshooting procedure.

3. Determination of the reason for the problem.
sort through all of the available materials and develop a procedure that works best for his needs.

**Types of Motors**

The types of motors applicable to this article are AC, single- and three-phase, squirrel cage, and induction. Sizes range from C-frame up through the two-digit frames -42, 48 and 56. Many of the procedures and tips are also applicable to larger motors.

Squirrel-cage and induction-type refer to the construction and operation of the rotor. Current is induced into the rotor as there are no brushes or other physical connections between the rotor and stator.

For three-phase motors, a three-phase current sets up a rotating magnetic field that produces the starting torque without additional components such as switches and capacitors, or separate windings.

In regard to single-phase motors, a single-phase current sets up a pulsating magnetic field, so single-phase motors use several different methods to start (Figures 1 and 2). Shaded-pole motors are the simplest, employing a copper shading bar on one side of each main stator coil.

Split-phase and capacitor-start designs have start windings that are taken out of the circuit by a mechanical or electronic switch after the motor reaches approximately two-thirds to three-quarters of full speed. Capacitor-start/run designs also have auxiliary windings, but they stay in the circuit in the run mode. On this design, the switch's function is to remove the start capacitor and connect the run capacitor. Permanent-split-capacitor (PSC) designs have main and phase windings, and a run capacitor, which is always in the circuit.

Connection information is a must for basic troubleshooting. A schematic, showing all circuits, also may be required in order to pinpoint a problem. In addition, an understanding of nameplate information is a necessity.

**Troubleshooting Procedures**

Safety should be the prime concern when troubleshooting or doing routine maintenance.
Treat every situation as potentially hazardous.

Minimum test equipment that should be on hand include a meter(s) to measure voltage, resistance and current. Digital versus analog may be a matter of personal preference, but the digital readout eliminates the need to interpret a reading. Additional equipment such as strobes to measure rpm, capacitor checkers as well as temperature measuring devices may be required for some applications.

The request for service usually relates to a piece of equipment or system that is not operating properly. Following an established procedure will lead to the point where the motor is the next logical part to be examined. The procedure is essentially the same for a motor that has been in service for years or a recently installed motor. It's basically a process of elimination until the problem is uncovered.

More than likely two scenarios exist: The motor either doesn't start, or it starts but doesn't perform properly. In either situation, begin with a visual check and be certain the power is off. Use the voltmeter to ensure that voltage is not present. Items to look for include:

- Are the motor and system properly grounded?
- Is there evidence of overheating such as discolored paint or deformed labels?
- Are there any burned wires or loose connections?
- Does the shaft turn freely?

You should not be able to detect radial (side to side) movement of the shaft in motors equipped with either ball or sleeve bearings. There should not be axial (in and out) movement of the shaft on ball-bearing motors. On the other hand, sleeve-bearing motors should have axial movement of approximately ten- to sixty-thousandths of an inch. Too little endplay can cause the motor to bind as it heats during operation. Too much endplay may indicate that thrust components are worn.

First let's consider a case where the motor doesn't start or starts and very quickly trips on overload, trips a breaker or blows a fuse.

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**Check For Shorts And Open Circuits**

If there is no obvious fault, disconnect the motor line leads and start the troubleshooting procedure. Connect the voltmeter to the line leads and restore the power to determine that power was available to the motor. Turn off the

If there is an open circuit and it includes a capacitor, discharge as above and check with a capacitor checker or ohmmeter. The capacitor checker is preferred since it will show performance values. If using an analog ohmmeter, set the scale to R (resistance) x 1K and touch a probe to each of the terminals. The needle should move rapidly to the
power and continue.

If the motor uses capacitors, discharge by touching across the line terminals with the blade of an insulated screwdriver. Use the ohmmeter to check continuity of motor circuits and for a short to ground.

It's possible for a turn-to-turn short to cause a rapid rise in current, which will trip an overload or breaker. Turn-to-turn shorts are easiest to detect if circuit diagrams and normal resistance values are known.

A resistance reading to ground of less than 10K may indicate a bad motor. New motors typically read over one megohm. Old motors with dust, dirt and moisture could show resistance to ground below 10K and still run satisfactorily. A cleaning may be in order.

Low resistance to ground does present a problem in GFCI (ground fault circuit interruptor) circuits. If the problem is not dirt and moisture, the motor must be replaced.

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**Not Up To Speed**

Be especially careful if there is not a power disconnect at the unit. If the motor has an automatic overload, it may start unexpectedly. In cases where mechanical start switches may not be opening, the motor will overheat and trip the overload. The switch contacts may weld together and quite often, if the motor has a start capacitor, it will fail.

If the motor has been operating properly, check for low voltage as it may indicate there is an external problem. On new installations, use the voltmeter to check for excessive voltage drop (more than 15 percent) as the motor tries to reach operating speed. This is also an external problem usually caused by undersized wiring.
In addition, loading may have changed due to failure or changed conditions in the driven equipment.

An Overheating Motor

If the motor reaches operating speed but overheats, use the ammeter to measure operating current. Compare the readings to those on the nameplate. If max amps are listed, they should not be exceeded. If this is a new installation, the motor is probably undersized. On an existing installation, try to determine if the loading has changed. Unequal readings on different legs of the power supply may be indicative of a turn-to-turn short, which may cause overheating.

Unbalanced phase voltage on three-phase motors, also known as singlephasing, causes overheating. Understanding phase unbalance is a study in itself. The percentage in additional temperature rise is equal to twice the percentage of voltage unbalance squared. Depending upon the severity of the problem, the motor may stop running or just have a shorter useful life.

If one phase drops out completely, the other two phases will rapidly overheat, possibly leading to immediate failure which is easy to identify.

Excessively low voltage will lead to eventual overheating. The motor should be capable of operating at ±10 percent of the nameplate rating. Use the voltmeter to check operating voltage.

High ambient temperature is a condition that may not be present at the time the motor is being checked. If the complaint is nuisance tripping, try to determine when it occurs. The motor nameplate should list the allowable ambient temperature: 40° C = 104° F; 60° C = 140° F. The 60° C ambient is common on condenser motors as it allows for actual ambient, plus heat pickup from the coil.

Determining The Reasons

If the cause of the problem isn't uncovered and corrected, there is a very good
probability that a replacement motor will also fail.

Obviously conditions such as improper voltage or a leaking pump seal must be corrected. On the other hand, a voltage surge during a thunderstorm cannot be prevented in the future. It may be difficult to determine that improper belt tension lead to a bearing failure. Finding and replacing a defective overload almost never addresses the real problem (Figure 4).

The concept here is to look beyond the actual failure mode. Access to the equipment's service history, if available, can be a real plus. Ask if the same motor or part is being replaced again and again. Obviously if a part or motor needs continual replacement, other problems not directly related to the motor may be the cause of the ailment.

As an example, let's take a look at a unit that experienced repeated condenser motor failures while identical units at the same site operated satisfactorily. The culprit was found to be the exhaust fan needed for a lunch counter. Hot, grease-laden air was being drawn through the condenser motor. The solution was a solid fence erected between the exhaust fan and air-conditioning unit.

Motor troubleshooting isn't something a person can learn overnight. While it's easy to determine a motor doesn't run and to install a replacement, the knowledge, experience and solid troubleshooting procedures often will lead to more satisfactory results. Continually taking courses offered through organizations such as RSES can go a long way to making you a top technician and motor troubleshooter.

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