Test tool for electrical motors

The four workhorses of motor troubleshooting and maintenance

Technology at Work

AC electrical motors consume 40 % of the power generated in the US. Imagine the overall troubleshooting and maintenance requirements for that much power consumption! To stay on top of it all, maintenance electricians rely on four principle tools.

When problems arise, the first tool of choice is usually a digital multimeter (DMM), such as the Fluke 87V. A good DMM can take a variety of measurements, from checking if power is present at all legs of a three-phase motor, to checking the motor start capacitor of a single-phase motor, or even to measuring heat.

But to measure temperature on a large number of motors and related instruments — especially in live electrical connections — a non-contact infrared thermometer with a large distance-to-spot ratio*, such as the Fluke IR66 or 68, is the only safe and efficient way to go.

Sometimes, the temperature you're sensing may result from current unbalance. In that case, reach for a clamp meter like the Fluke 337, and trace the cause — because it could be one of several different factors.

And to detect the most subtle of all problems — insulation resistance and degradation — nothing beats a MegOhmMeter like the Fluke 1520. If a currently functioning motor is about to go down, your MegOhmMeter can tell you before it's too late.

When the need arises to make live measurements in a 3 phase panel observe the following safe work practices:

1. Wear the appropriate Personal Protective Equipment (PPE) for the measurement at hand and the environment.
2. Make sure your test instrument is rated for the measurement environment. In this case Category III 600V or higher would be appropriate.
3. Use the three point test method.
4. Generally, keep one hand in your pocket unless you must use both hands to obtain a proper measurement.

This application note describes how to use these tools to troubleshoot and monitor four principle indicators: temperature, current, voltage, and insulation resistance.

*Distance to spot ratio calculates from how far away an infrared thermometer can accurately measure a particular target area.

Temperature

A rise in temperature is a good indicator that something's wrong. An infrared thermometer makes quick temperature comparisons a snap; press the trigger to take the first measurement, save it, refocus on the second target, and measure again. One switch running 30 degrees hotter than the others is a sure sign the contacts are failing.

Using an infrared thermometer to quickly measure bearing heat.

Motor case temperature is another good place to start troubleshooting, but you have to know what is normal, to know whether your new reading is unusual. Therefore: make a habit of taking baseline temperature measurements of motors when they are newly installed and running well, and then repeat that measurement on a regular basis.

Another problem to watch for on a long-term basis is potential bearing failure. A shaft bearing will run hot for days perhaps before full failure. To avoid replacing the entire motor, regularly measure the bearing housing and compare the result to the baseline temperature. (See Fluke Application Note 2278935 for detailed instructions on infrared thermometer troubleshooting.)

Current

Another root cause for motor overheating is current unbalance. Use an ac current clamp meter to check the current draw on each of the three legs. To determine average current, sum the current from all three phases and divide by three. Then, calculate the percent unbalance by subtracting the actual on one leg from the average.

Peeling the onion back further, current unbalance can be caused by several different sources: a power delivery problem, low voltage on one leg, or an insulation resistance breakdown inside the motor windings. In the maximum case of unbalance, single phasing, one entire phase is lost and the fuse blown.

The best measurement tool to detect single phasing is the clamp meter: a zero current measurement in one phase is a clear indication of power loss. However, a voltage measurement on the same phase can be misleading, due to induced current from the two remaining live phases. A 150V "ghost voltage" reading around two 240VAC live circuits is not uncommon.

To verify whether a fuse is blown, removed the fuse from the circuit and use the resistance function on a DMM or a clamp meter to check the fuse. Once the fuse has been removed from the circuit place the multimeter or clampmeter in the ohms (Ω) function. Place the test probes at each end of the fuse. A good fuse will measure as a very low resistance (less than 10 ohms). An open fuse will show as an "OL" in the meter display.Check and double check your measurements: many troubleshooters have been fooled by assuming they know the real cause. Don't jump to a conclusion before testing all circuit elements.

$$\textbf{average amps} = \frac{\textbf{ph1 amps + ph2 amps + ph3 amps}}{3}$$

$$\textbf{\% unbalance on phase 1} = \frac{\textbf{ph1 amps - average amps}}{\textbf{average amps}} \times 100$$

Example

1. Measure all 3 phases, add together, and divide by 3.

$$\frac{9.9 + 10 + 10.1}{3} = 10$$

2. Calculate percent unbalance on phase 3.

$$\frac{10.1 - 10}{10} \times 100 = 1\ \%$$

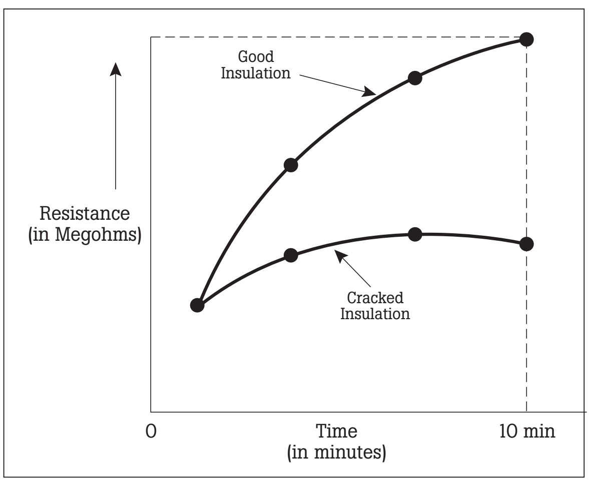
Voltage

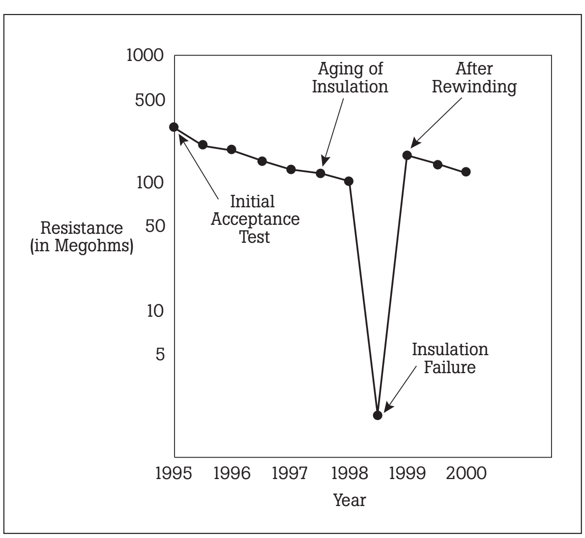
When checking for voltage problems, the multimeter is again the tool of choice. First, check the protection and switchgear for voltage drops. If you don't detect anything there, you may have a utility delivery problem. A greater than 2 percent unbalance in power delivered from the utility can harm your motors. Voltage unbalance can be calculated with this formula

$$\textbf{average volts} = \frac{\textbf{ph1 volts + ph2 volts + ph3 volts}}{\textbf{3}}$$

$$\textbf{\% voltage unbalance on phase 1} = \frac{\textbf{ph1 volts - average volts}}{\textbf{average volts}} \times \textbf{100}$$

However: loads do change, and a phase can suddenly be 5 percent lower on one leg. Voltage drops across the fuses and switches can also show up as unbalance at the motor and excess heat at the root trouble spot. Before you assume the cause has been found, double check with a few different tools. In this instance, the IR thermometer complements both the multimeter and the clamp meter current measurements.





Insulation Resistance

By measuring the resistance of motor windings from each other, you can detect deterioration due to age, corrosion, dirt, moisture and excessive vibration, before the motor fails. Disconnect the motor from power and then hook up a MegOhmMeter across the windings. To measure high resistance, apply a high voltage — up to twice the working voltage. On a 480 V motor for example, you'd apply 1000 V. Take your reading in megohms. For a 240-480 V rated motor, 300 K ohms is the minimum acceptable resistance.

Since insulation resistance varies with temperature and humidity, you may need to take several resistance measurements over a period of time to get an accurate result. Periodic insulation resistance measurements will tell you how healthy your motors are, and when to replace or re-wind them.

Use individually or in combination

To summarize, the four basic tools for motor troubleshooting and maintenance are:

- A digital multimeter to check voltage, resistance and capacitance
- A clamp meter to check current draw
- An infrared thermometer for temperature affects
- A MegOhmMeter for insulation resistance measurements

Used in combinations, these four tools allow technicians to double-check symptoms and troubleshoot the root cause of almost any electrical motor failure.

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