

# Electrical, insulation and thermal measurements for motors and drives

**Insulation multimeters and thermal imagers: Two testers that go great together.**

**Application Note**

Most facilities need to get maximum life out of their motors, because they are expensive to replace in terms of both money and labor. Electrical, insulation resistance and thermal measurement are three tests that can troubleshoot motors, drives, and associated electrical panels and prolong their operational lifetime. Use together, thermal imagers can detect potential problems and insulation resistance and electrical tests can determine the cause.

Handheld thermal imagers such as the Fluke Ti25 can collect heat signatures from a range of motors, from 1000 hp down to 5. A thermal imager is good for spot checks, to see if motors and associated panels and controls are operating too hot, and for troubleshooting, to track down the specific failed component at fault. It can also check for phase imbalance, bad connections, and abnormal heating on the electrical supply.

An insulation multimeter like the Fluke 1587 can perform most of the other tests you need to troubleshoot and maintain motors. When a motor is having problems, check the supply voltage and then use insulation testing to check the starter and control contacts, measure the insulation resistance of the line and load circuits to ground, and winding resistance phase to phase and phase to ground.



# About thermal measurements

A motor's heat signature will tell you a lot about its quality and condition. If a motor is overheating, the windings will rapidly deteriorate. In fact, every increase of 10 °C on a motor's windings above its design operating temperature cuts the life of its windings' insulation by 50 percent, even if the overheating is only temporary.

If a temperature reading in the middle of a motor housing comes up abnormally high, take a thermal image of the motor and find out more precisely where the high temperature is coming from, i.e. windings, bearings or coupling. (If a coupling is running warm it is an indicator of misalignment.)

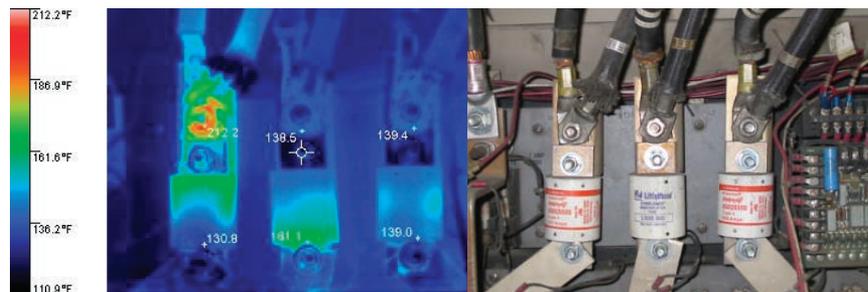
There are three primary causes for abnormal thermal patterns; typically most are the result of a high-resistance contact surface, either a connection or a switch contact. These will usually appear warmest at the spot of high-resistance, cooling off the further away from the spot. This thermal image shows a classic pattern in the center phase connection on the line-side of a breaker; note how the conductor cools off at the top of the image.

Load imbalances, whether normal or out of specification, appear equally warm throughout the phase or part of the circuit that is undersized/overloaded. Harmonic imbalances create a similar pattern. If the entire conductor is warm, it could be undersized or overloaded; check the rating and the actual load to determine which.

Failed components typically look cooler than similar, normally functioning ones. The most common example is probably a blown fuse. In a motor circuit this can result in a single phase condition and, possibly, costly damage to the motor.

## Examples

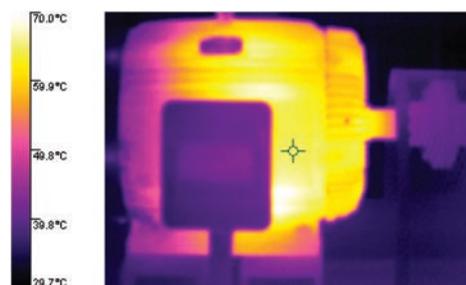
This thermal image shows a drive cabinet with hot connections on both A and B phases. The exact cause can't be determined solely from the image, although it may be a load or balance issue.



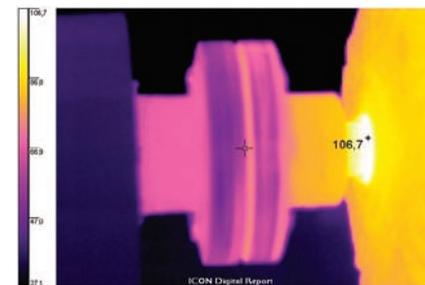
This image shows a warm bearing (or seal) on the pump. Clearly the access is tight but we can still compare the bearing to the housing around it.



This image shows another bearing problem with heat also transferring into the coupling on the right side.



This image shows the motor itself heating up, due to reduced airflow or, more probably, to misalignment.



Fluke thermal imagers now include IR-Fusion®\*, a technology that fuses a visual, or visible light, image with an infrared image for better identification, analysis and image management.  
\*The Fluke Ti20 comes with InSideIR™ analysis and reporting software with free updates for the life of the product.

## About insulation resistance testing

Insulation problems on motors and drives are usually caused by improper installation, environmental contamination, mechanical stress or age. Insulation testing can easily be combined in with regular motor maintenance, to identify degradation before failure, and during installation procedures to verify system safety and performance. When troubleshooting, insulation resistance testing can be the missing link that enables you to get a motor back into operation the easy way, by simply replacing a cable.

Insulation testers apply a dc voltage across an insulation system and measure the resulting current. This allows them to calculate and display the resistance of the insulation. Typically, the test verifies high insulation resistance between a conductor and ground or high insulation resistance between adjacent conductors. Two common examples include testing motor windings for insulation from the motor frame and checking phase conductors for resistance from bonded conduit and enclosures.

Insulation multimeters combine the insulation resistance functions above with the other tests needed to investigate motor, drive, and electrical trouble, from basic supply measurements to contact temperature. The key difference is that insulation resistance tests are performed on de-energized systems, while electrical tests (and thermal) are almost always performed on live, operating systems.



### Electrical and insulation resistance tests on motors

#### 1. Visual inspection

First, look for a reason NOT to energize. Remove power from the motor and starter (or drive), following lockout/tagout procedures, and disengage the motor from the load.

- Conduct a visual, smell, and heat inspection, interview the client and check the nameplate. Look for loose connections at the starter and check all fasteners.
- Use a DMM to check the supply voltage, then the voltage starter contacts.

Don't risk a fire from a possibly shorted motor. If the supply is good, then there's a motor problem.

#### 2. Control contacts check

Next, check the control contacts for quality of contact:

1. Lockout and tagout the disconnect to the starter.
2. Manually engage the starter, so the contacts close.
3. Set the insulation tester to the low ohms range.
4. Measure the resistance across each set of contacts.
5. The reading should be nearly zero. If it's higher than 0.1 ohms, that set of contacts needs to be replaced.

### 3. Resistance of line and load circuits to ground

Then, measure the insulation resistance of the line and load circuits to ground. However, **before doing ANY insulation resistance testing, you MUST isolate any electronic controls and other devices from the circuit under test.** Then:

1. Lockout and tagout the disconnect to the starter.
2. Set the insulation tester to the appropriate test voltage (250, 500 or 1000 V).
3. Identify the resistance between these points:
  - Line side of starter to ground
  - Load side of starter to ground

To pass these tests, the line and load circuits need to show high resistance.

**As a general rule, ac devices need a minimum 2 megohms to ground and DC devices need 1 megohm to ground to ensure safe operation.**

**Note:** Different companies have different threshold minimums for insulation resistance on used equipment, ranging from 1 to 10 megohms. Resistance on new equipment should test much higher—from 100 to 200 megohms or more.

If the load side resistance values are acceptable then proceed to the next test. If they aren't, then start tracing the problem: is the insulation breakdown in the load side of the starter, the cables, or the motor?

### 4. Winding resistance phase to phase and phase to ground

Take insulation resistance measurements phase to phase and phase to ground.

**Good results:**

- Balanced comparative low resistance values on all three stator phases
- High resistance values on the phase to ground insulation test

**Problems:**

- Gross resistance deficiencies, such as a phase on phase short.
- Any winding to winding resistance imbalance. If the readings differ by more than a few percent, the motor is probably unsafe to energize.



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