FLUKE®

Monitoring transformers

Application Note

Most transformers are cooled by either oil or air while operating at temperatures much higher than ambient. In fact, operating temperatures of 65 °C for oil-filled units and 150 °C for air-cooled transformers are common. Nevertheless, problems with transformers often manifest themselves in overheating or hot spots, making thermal imaging a good tool for finding problems.

Power and distribution transformers change electric current from one voltage to another. They accomplish this process when electricity flowing through a coil at one voltage induces current in a second coil. The amount of change is a function of the number of windings on the coils.

The following discussion focuses on monitoring external and internal conditions of oil-filled transformers. Dry transformers also can exhibit both external or internal connection problems, and external connection problems can be detected as with oil-filled units. Beyond that, dry transformers have coil temperatures so much higher than ambient, it is difficult to detect internal problems before irreparable damage occurs. Other diagnostic technologies, including built-in temperature and pressure gauges, may be more reliable for assessing the internal conditions in dry transformers.

The procedures described here should be conducted in conjunction with the recommendations of NFPA Standard 70B, *Recommended Practice for Electrical Equipment Maintenance, Chapter 9: "Power and Distribution Transformers."*

What to check?

At a minimum, use your thermal imager to look at external connections, cooling tubes and cooling fans and pumps as well as the surfaces of critical transformers.

What to look for?

In oil-filled transformers, monitor the following external components:

- **High- and low-voltage bushing connections.** Overheating in a connection indicates high resistance and that the connection is loose or dirty. Also, compare phases, looking for unbalance and overloading.
- **Cooling tubes.** On oil-cooled transformers, cooling tubes will normally appear warm. If one or more tubes are comparatively cool, oil flow is being restricted and the root cause of the problem needs to be determined.

At 94 °F (34ºC), one of the terminals on this 1320 V – 480 V main tranformer is running hotter than it should.

For more information on Thermal Imagers go to **your local Fluke web site.**

- **Cooling fans/pumps.** Inspect fans and pumps while they are running. A normally operating fan or pump will be warm. A fan or pump with failing bearings will be hot. A fan or pump that is not functioning at all will be cold.

Problems with surge protection and lightning arrestors leaking to ground and current tracking over insulators can also be detected using thermography. However, finding such problems requires the capture of subtle temperature differences often under difficult-to-monitor conditions. Ultrasound or some other technology might be a more reliable monitoring technique for these problems.

For thermography to be effective in pinpointing an internal transformer problem, the malfunction must generate enough heat to be detectable on the outside. Oil-filled transformers may experience internal problems with the following:

- **Internal bushing connections.** Note: connections will be much hotter than surface temperatures read by an imager indicate.
- **Tap changers.** Tap changers are devices for regulating transformer output voltage to required levels. An external tap changer compartment should be no warmer than the body of the transformer. Since not all taps will be connected at the time of an inspection, IR inspection results may not be conclusive.

A good approach is to create regular inspection routes that include the transformers on all essential electrical circuits. Save thermal images of each one on the computer and track temperature measurements over time, using the software that comes with the IR camera. That way, you'll have baseline images with which to compare later images that will also help you determine if temperature levels are unusual and, following corrective action, determine if maintenance was successful.

What represents a "red alert?"

Equipment conditions that pose a safety risk should get the highest priority for repairs. However, the imminent failure of any piece of critical equipment constitutes a red alert. Key operations, maintenance and safety personnel should play roles in quantifying "warning" and "alarm" levels for the power supplies to critical assets. (Note: alarm levels for specific equipment can be set on Fluke handheld thermal imagers.) Throughout, personnel responsible for monitoring transformers should keep in mind that like an electric motor, a transformer has a minimum operating temperature that represents the maximum allowable rise in temperature above ambient, where the specified ambient is typically 40 °C. It is generally accepted that a 10 °C rise above its maximum rated operating temperature will reduce a transformer's life by 50 percent.

What's the potential cost of failure?

For power delivery companies, transformer failures can be very costly. A transformer failure in the summer of 2005 in Oslo, Norway resulted in a 50-minute power outage for 200,000 customers, left people trapped in subways and elevators, and cost the power delivery company responsible for the transformer 10 million Norwegian kroner (≈ €1.28 million) in compensation to NVE, Norway's main power supplier.[2]

For a failed transformer at your facility, you can do an analysis of the cost of repair or replacement, lost production opportunity and lost labor costs for affected equipment.

Follow-up actions

Whenever you discover a problem using a thermal imager, use the associated software to document your findings in a report, including a thermal image and a digital photograph of the equipment. That's the best way to communicate problems you find and to suggest repairs.

Perceived internal problems in oil-cooled transformers can often be verified by a gas-in-oil analysis. The presence of methane in the oil indicates overheating. Acetylene indicates arcing. This test can also be used to help trend the severity of a problem in a transformer that simply cannot be taken down for repairs. **Warning:** Never draw liquid samples from an energized transformer except via an external sampling valve. Also, regular gauge and load monitoring and visual inspections for leaks, corrosion, et cetera will help guide further maintenance activities. In any event, follow the guidance of NFPA 70B, Chapter 9.

[1]Background information supplied by John Snell & Associates.
[2]Source: www.aftenposten.no/english

Imaging tip

Winds (or air currents inside) in excess of even a few miles per hour will reduce the surface temperatures of transformers and other equipment, causing real problems to seem less significant or even making them undetectable by your thermal imager. Inside plants, air currents are often 10 to 15 miles per hour. Buy a high-quality wind meter and use it. When you must inspect in high convection situations, note all problems for a follow-up inspection. Even small temperature increases may become critically hot when airflow is reduced.

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