Infrared Tells More Than Temperature

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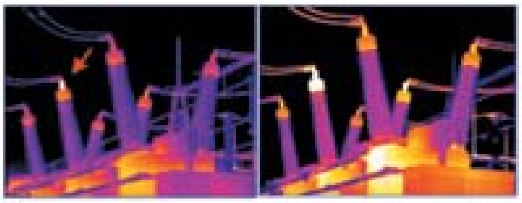

The cooling effect of wind on overheated equipment is evident in these two infrared images of an oil-filled circuit breaker. The image at left, taken when winds were 15 mph, shows a connection which has heated to 20 degrees F above ambient temperature (arrow). The right image, taken when winds were only 2 mph, shows the same bushing heated to a more dangerous 38 degrees F over ambient, as well as another developing problem (bottom center).

Investments in infrared thermography will return handsomely when used as part of a well-planned maintenance program. Unfortunately, many companies don't get those returns. In fact, thermography all too often becomes a burdensome expense, and the program is eventually abandoned. One reason this happens is because managers fail to understand the basics of the technology and the needs of their staff who use it.

The best use of thermography is locating potential problems, not measuring temperatures. This is difficult for many managers to accept since they were probably sold the technology based on its measurement capabilities. Measuring temperatures may be useful, but it is not the highest use of the technology. Used properly, an electrical inspection will quickly reveal the high-resistance problems that, over time, result in unscheduled outages. Thermal images of mechanical systems can clearly show impending failures that are impossible to detect otherwise.

What is necessary to detect these anomalies reliably and consistently? A basic understanding of heat transfer and radiometric measurement is essential. Infrared cameras can detect radiant differences on many surfaces when temperature differences of less than one degree Fahrenheit exist. This is why it is so easy to see the thermal signature of a handprint left on a wall.

If the surface is unpainted metal, however, especially aluminum or copper, it is impossible to detect such small temperature differences. Basic physics says these surfaces emit thermal energy (heat) inefficiently. For the camera to detect a radiant difference, the temperature difference must be larger than one degree. In fact a high-emissivity surface at 129 degrees F (54 degrees C), and a low-emissivity surface at 399 degrees F (204 degrees C) (399F) both radiate the same energy and would look similar in a thermal image. Because the relationship between emitted heat and temperature is tenuous for low-emissivity surfaces, the temperatures displayed in thermal images are often inaccurate.

Unfortunately, despite what many believe, accurate temperatures cannot be achieved simply by adjusting the infrared camera using the right "emissivity correction value." While it is usually possible to make corrections for high-emissivity surfaces like insulation or painted metals, measurements of unpainted metal surfaces will be unreliable, at best, and more typically, they will be highly inaccurate. This is unfortunate since temperature values may be useful in determining the true nature of a finding.

To get good results, it is essential to pay attention to environmental and system conditions. Hot anomalies can be cooled below the threshold of detection by wind or inside air currents. When wind exceeds 10 mph, some problems cannot be seen, whereas those that are seen will appear cooler (and, as a result, many might incorrectly assume to be "less serious").

Indoors or out, it is useful for thermographers to have a "personal weather station," which will enable them to measure wind speeds and air currents and understand the impact on their findings. These measurements need to be published in the report; without this data, temperature measurements are of little value. For example, past electrical inspection practices of opening a row of enclosures, then conducting the inspection meant equipment cooled down in the process, and that affected results. Procedures for indoor electrical inspection should be modified so that only a few enclosures are opened at a time.

In addition to environmental conditions, good results depend on paying attention to system conditions as well. Many inspections have been conducted with little regard for loading conditions. Under light load conditions, problems related to abnormal electrical resistance or excessive mechanical friction may not be evident. Some managers, failing to understand this fact, have even scheduled work during shutdowns because they believed it was more convenient! The National Fire Protection Association's NFPA 70B Maintenance of Electrical Equipment suggests that infrared electrical inspections be conducted with a 40% of load or greater. For systems, such as electrical distribution networks where loads will, at some point, reach a design maximum, even a 40% minimum will not necessarily produce detectable thermal signatures. The problems still exist but cannot be seen.

To make matters worse, the relationship between temperature and the progression to failure is not well understood and is most often not even predictable. That electrical connections should generally operate at or near ambient air temperature is a given. The temperatures at which metals melt or greases fail to function or, in extreme cases, at which combustion begins are also all well known. These "alarms" are not, however, very useful in helping us prevent excessive damage to our machine assets.

Despite the widespread use of the term "predictive maintenance," completely accurate prediction of the time to failure is, of course, not possible. The best we can do and this is immensely valuable is to locate problems, hopefully well in advance of failure. Further, when inspections are done by skilled thermographers using the right equipment properly, that kind of information is available with a very high degree of reliability. With that key information in hand, a manager can then decide which actions to take to manage the problem to a successful conclusion.

It's important to stress the importance of having skilled thermographers on staff. Managers are often tempted to buy new, expensive infrared cameras rather than invest in the people using them. Today's equipment is remarkable lighter, more fully featured, easier to use, and less expensive but why buy a new system if the old one is sitting on a shelf unused? Learning to use the latest cameras is not difficult. Learning to interpret the results, however, is just complex enough that it takes some basic training and hands-on experience to become accomplished. For a thermographer to become an expert, and produce world-class results, management must commit to continuing education, time to set up and implement the program, and systems that fully integrate thermography into the maintenance program.

Consulting thermographers can play a role in a successful program as well. In small plants, it may never be cost effective to provide thermography services from inside. Consultant day rates vary around the U.S. from $400 to $1200, a wide range that also usually reflects quality and scope of the service. Look carefully at the qualifications of the consultant as well as the scope of what they are able to provide. After an initial trial period, it may be useful to enter into a multi-year agreement so you can include the consultant into the process of building the program. Make certain that you have equipment lists and priorities ready when they arrive and devote one of your best maintenance people as an escort.

One outcome of a successful infrared-based maintenance program is to minimize or eliminate unscheduled downtime due to heat-related problems. For this to happen, however, thermography must be used appropriately, and the program and personnel must receive adequate support from management.