FLUKE®

Substations and Switchgear

Application Note

Substations call for a predictive approach to maintenance because a failure can be costly for end users in terms of lost production and revenues and lead to lower revenues for the utility from lost sales due to unreliable service.

Since overheating as well as abnormally cool operating temperatures may signal the degradation of an electrical component, thermal imagers provide the predictive capabilities required for substation and switchgear maintenance.

In the power generation and distribution industries, the term substation is used in many ways. Various outdoor facilities ranging from switchyards at generating stations to equipment at utilities or at industrial facilities that switches or modifies voltage, frequency or other characteristics of primary power are called substations.

Predictive maintenance (PdM) helps ensure the quality of an end user's electricity by enhancing the reliability of substations. PdM accomplishes this increased reliability by monitoring equipment over time in order to isolate conditions that indicate impending failure. The goal is to determine whether corrective action is required and, if so, to take that action before equipment fails.

For equipment that always has a high operating temperature, establish a baseline or standard acceptable temperature range to compare readings to.

One set of tools for monitoring equipment in substations is Fluke's handheld thermal imagers. Thermal imagers capture two-dimensional representations of the apparent surface temperatures of electrical components and other objects.

What to check and when?

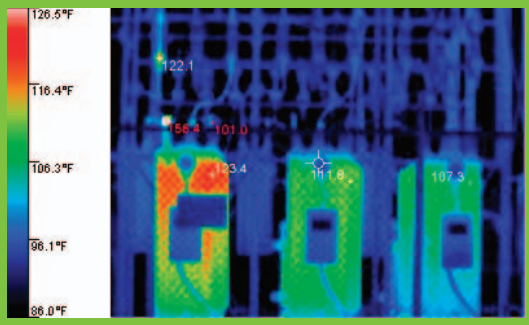
For a detailed outline of maintaining substations and related switchgear assemblies, follow NFPA Standard 70B, Recommended Practice for Electrical Equipment Maintenance, Chapter 8: "Substation and Switchgear Assemblies." That standard explains that in transforming primary power, substations may provide system protection, power-factor-correction metering and circuit switching in addition to changing voltage. Substations and switchgear inherently operate at high voltages. NFPA standard 70E provides additional specific guidance on procedures and the level of personal protective equipment required when inspecting substations. Thermal inspectors typically inspect transformers, regulators, switches, circuit breakers and capacitors among other components.

The time of day is an important factor in collecting thermal images of substation components. Readings in the stillness of early morning may avoid the effects of solar reflections and wind, which can skew temperature readings. However, in pre-dawn hours loads are generally lighter and problems less detectable. The training and experience of the thermographer may also affect when outdoor IR scans should be performed.

What to look for?

Following a thorough inventory of the equipment in a substation, scan the entire substation yard, saving images of any known or possible anomalies. Look especially for similar pieces of equipment under similar loading that are clearly operating at different temperatures.

A good thermographic approach to substation maintenance is to create inspection routes that include all the substations owned by your utility or facility. On a computer, save thermal images of each substation component and track temperature measurements over time. That way, you'll have baseline images with which to compare later images. Doing this will help you determine if tempera-



This thermal image shows hot secondary connections on the transformer.


Examine transformers, comparing similar connections under similar loads.

ture levels are unusual and, following corrective action, help you determine if maintenance was successful.

What represents a "red alert?"

Equipment conditions that pose a safety risk should receive the highest repair priority. Beyond that, NETA (InterNational Electrical Testing Association) guidelines say that when the temperature difference (T) between similar components under similar loading exceeds 15 °C (27 °F) immediate repairs should be performed. NETA also recommends the same action when theΔT between a component and ambient air exceeds 40 °C (72 °F).

Following this line of thinking, one way to categorize maintenance tasks and flag equipment urgently needing repairs is to monitor substation equipment for specific degrees of temperature rise above established reference points. Knowledgeable technical, safety and maintenance personnel might establish these limits to range from "continue to monitor" to "correct immediately," with other levels of action such as "schedule maintenance" or "repair as soon as possible" in-between.

This approach has been successful when reference points take into account the differences between line-of-sight scans (e.g., metal-to-metal contacts in switchgear) and non-line-of-sight situations (e.g., the internal components of transformers), where heat is dissipated or obscured from the direct view of the thermographer and the IR camera. In a non-line-of-sight scan, the actual operating temperature will be much higher than the IR camera registers, so the reference points that signal what corrective action to take must be much lower. Also, abnormally cool as well as abnormally hot components should be included in the mix.

What's the potential cost of failure?

The costs associated with a failed electrical substation depend upon many factors including the number and types of customers affected. One source*, estimates the average hourly cost of downtime across all industries at nearly $950,000.

Follow-up actions

Whenever you discover a problem using a thermal imager, use the associated software to document your findings in a report that includes a digital, visual-light image of the equipment and a corresponding thermal image. That's the best way to communicate any problems you found and to make any suggestions for correcting them. Following corrective action, a new thermal image can be used to assess the effectiveness of repairs and evaluate the materials and techniques used. With this information, you can continuously improve your maintenance program for substations.

*IT Performance Engineering and Measurement Strategies: Quantifying Performance and Loss, Meta Group, Oct. 2000; Fibre Channel Industry Association as found on the Web site of the Association of Contingency Planners, Washington State Chapter: www.acp-wa-state.org.

An imaging tip:

Consider performing IR scans of substations during the winter and early spring months rather than during the summer when loading is the highest. In the summer, it is more difficult for maintenance personnel to get authorization for shutdowns for repairs. However, during peak loading in the summer is when equipment is most likely to fail. Repairs made in winter and spring will put equipment in tiptop condition to meet the demands of summer.

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