

Inspecting electrical vaults

Application Note

In the electrical distribution industry, transformer vaults play key roles in converting primary line voltage to secondary voltage(s) for delivery to customers. Typically crammed full of equipment and often below ground level, these bunker-like structures call for a predictive approach to maintenance because a failure within a vault can be costly, dangerous and bad for a utility's business and reputation.

Predictive maintenance (PdM) involves monitoring equipment over time for conditions that indicate impending failure. The goal is to determine whether corrective action is required and, if so, take that action before the equipment fails with potentially catastrophic consequences.

One powerful set of tools for monitoring equipment in electrical vaults are handheld thermal imagers, also known as infrared (IR) imagers. Thermal imagers capture two-dimensional representations of the apparent

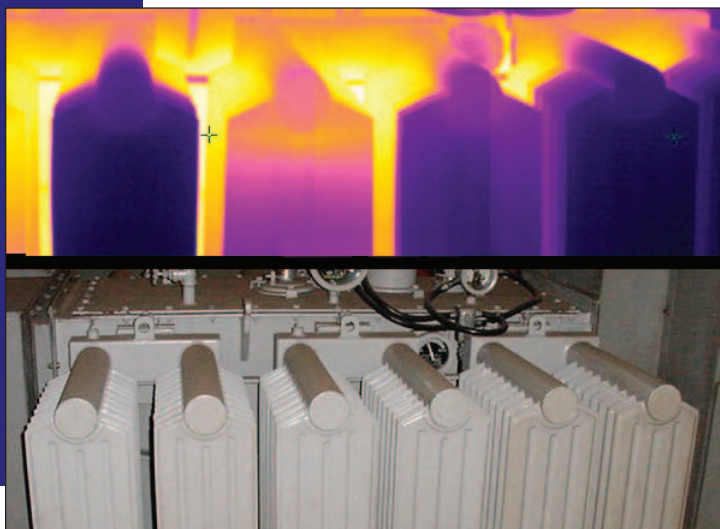
surface temperatures¹ of electrical components and other objects. And since overheating as well as abnormally cool operating temperatures may signal the degradation of an electrical component, imagers provide the predictive capabilities required to detect potential problems before they become costly failures.

¹ Apparent temperature is often significantly different from actual temperature; the difference attributable generally to the emissivity of a material's surface. An understanding of emissivity and the thermal characteristics of materials is crucial in understanding the apparent temperatures displayed by infrared images.

What to check?

Extreme caution is paramount for thermographers and support personnel preparing to enter an electrical vault. NFPA standard 70E provides specific guidance on procedures and the level of personal protective equipment required when inspecting this type of equipment. Check for flooding, poor or hazardous air quality, confining work clearances, poor lighting and any other conditions that could impede work or lead to an injury (or worse). Then, before entering the vault, perform a preliminary IR scan of equipment inside from the outside. **If a potentially hazardous situation presents itself, do not enter the vault.**

When you are sure that entry is safe and are inside, scan transformers, breakers, contacts, bus and fuse connections, fuse clips and any other equipment that supports the voltage conversion to customer requirements or sustains the integrity of the vault itself.



Transformers like the oil-cooled unit featured here are often found in electrical vaults and can be quickly scanned for potential failure points.

What to look for?

For transformers, follow NFPA Standard 70B, *Recommended Practice for Electrical Equipment Maintenance*, Chapter 9: "Power and Distribution Transformers." Monitor high- and low-voltage bushing connections, cooling tubes and cooling fans and pumps. Overheated connections, comparatively cool cooling tubes and hot or cool pumps or fans indicate potential problems.

Thermography is less effective for pinpointing internal transformer problems because a malfunction must generate enough heat to be detectable on the outside of the unit. When overheating is detected, be aware that internal components and connections are much hotter than surface temperatures indicate.

Regarding breakers, contacts, fuse clips and buss, fuse, stub and other connections, before you scan them, measure the load, so that you can properly evaluate your measurements against normal operating conditions. In general, look for spots that are hotter than other similar connections. They signal high resistance possibly due to looseness or corrosion. **Caution:** In checking transformer and other connections, if removing protective boots or opening panels is required, only qualified personnel using appropriate personal protective equipment should perform these tasks.

A good thermographic approach to electrical vault maintenance is to create vault inspection routes that include all the vaults owned by your utility. Remember, each vault is essential to one or more of your customers. On a computer, save

thermal images of each vault component and track temperature and associated data over time. That way, you'll have baseline images with which to compare later images. Doing this will help you determine if temperature 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, 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 (104 °F). It is generally accepted that a 10 °C (18 °F) rise above its maximum rated operating temperature will reduce a transformer's life by 50 percent.

Regarding other equipment, NETA (InterNational Electrical Testing Association) guidelines say that when the temperature difference (ΔT) between similar components under similar loading exceeds 15 °C (27 °F) immediate repairs should be performed. NETA also recommends the same action when the ΔT between a component and ambient air exceeds 40 °C (72 °F).

What's the potential cost of failure?

The cost of a failed electrical vault to a utility depends upon many factors including the number and types of customers affected the proximity of the vault to an area of high traffic or

human occupancy, whether a fire or explosion occurred and whether there was any resulting injury or death. Other factors aside, regarding downtime costs to a utility's customers, here are some representative hourly downtime costs for selected industries: Brokerage Operations, US \$6,450,000; Credit Card Sales Operations, US \$2,600,000; Manufacturing > US \$1,600,000. These figures are tied to loss of IT performance, but are cast in terms of general downtime.*

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 photograph of the equipment and a corresponding thermal image. It's the best way to communicate the problems you found and any suggestions for correcting them. Following corrective action, a new thermal image can be used to assess its effectiveness and evaluate the materials and techniques used. With this information, you can continuously improve your maintenance program for electrical vaults.

*Source: 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.

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An imaging tip:

When entering an electrical vault, always leave someone at the entrance with instructions not to enter the vault under any circumstances. This person's job is to keep unauthorized people a safe distance from the vault entrance and in the event of an emergency to call for help and avoid becoming a victim, too.