FLUKE®

Wisconsin electric co-op embraces in-house thermography

Application Note

Testing Functions
Case Study

Tool: Fluke Ti Series Portable Thermal Imagers

Profile: Keith Weyh, technical services supervisor at Adams Columbia Electric Cooperative

Inspections: Substations, power lines and utility transformers, as well as monitoring co-op equipment and facilities at dairy farms and other key accounts

Using a handheld infrared imager, Keith Weyh, technical services supervisor at Adams Columbia Electric Cooperative, monitors the health of the co-op's equipment, the equipment of its members, and sometimes even the equipment of the transmission company supplying its substations.

Adams Columbia Electric Cooperative monitors equipment health using thermography.

Bringing thermography in-house allows Weyh to help protect expensive equipment by scanning the ACEC-owned facilities on the sites of key co-op members.

The Adams Columbia Electric Cooperative (ACEC) serves about 35,000 members in 12 mostly rural counties in central Wisconsin. Of course, many members are dairy farmers, but the cooperative also serves about 13,000 seasonal residences, 600 irrigation services, approximately 1,500 small commercial accounts, and nine large facilities, including a chicken processing plant, an ethanol plant and a federal prison. To service these members, ACEC has 28 substations, more than 5,000 miles of power lines (about 2,700 miles underground and approximately 2,400 miles overhead), and the related equipment.

Until early in 2004, ACEC contracted with Wisconsin Public Service Corporation (WPSC) to do the co-op's thermography (or thermal imaging). Annually, a WPSC technician used a thermal imager—also called an infrared (IR) camera—to make two-dimensional representations of the surface temperatures of equipment in the co-op's substations. What those images sometimes revealed were hot spots on the equipment, which typically means a component is likely on its way to failure and should be serviced.

If an inspection uncovered what appeared to be a critical problem, a supervisor was called to request that a line crew make repairs. There was no provision for follow-up imaging to determine if effective repairs were made. In one case, it was two years between the detection of a failing regulator and confirmation that it had been repaired.

Justifying a camera purchase

Clearly, the outsourced, once-a-year inspections were not getting the job done. That fact —and several other factors— led to the decision to bring thermography in house.

One important issue was the need to protect expensive equipment. A substation transformer costs about $200,000. A 2000 kVA commercial transformer costs $19,000, and a regulator costs $15,000. The co-op has more than 100 regulators in its system. Keeping just one of them from being destroyed would nearly pay for the imager ACEC was considering.

Another factor influencing the decision to stop outsourcing thermal imaging was the desire to reduce overtime work caused by outages. In a single year, the co-op spent nearly $900,000 after hours to deal with outages. That figure included labor, benefits and transportation, but did not include the cost of materials or costs for outages handled during normal working hours. The imager the co-op was considering could be purchased for only two percent of after-hours overtime costs, so it easily would pay for itself in outages prevented.

Given these considerations, ACEC management set about securing an IR camera for the organization with the understanding that Keith Weyh would do most of the thermography. Weyh, a long-time lineman and the co-op's current technical services supervisor, assisted in the selection process. Early in 2004, the utility purchased its own thermal imager: a Fluke Ti40 (formerly the IR FlexCam® T from Infrared Solutions). Weyh says that he preferred the camera based on ergonomics and ease of use.

Thermal imaging at ACEC

With no formal training, Weyh was able to begin using the new camera right away. He attributes his ability to do that to his years of experience in the electric utility service sector, his experience using a handheld, non-contact IR thermometer, and personal research. Weyh says that training might be helpful, but what he looks for with the IR camera is pretty simple. One just needs to understand emissivity—or in other words, understand that not all energy emanating from an object is emitted by the object—and then know what to do in situations where reflected heat may be affecting an IR image.

Today, Weyh, armed with this knowledge and his thermal imager, inspects the co-op's equipment, the equipment of members and sometimes even the equipment of the transmission company supplying power to ACEC's substations. Here, in part, is what he inspects and how:

Substations. When he arrives at a substation, Weyh quickly scans the entire unit from a distance. Often, that initial scan will pinpoint problems immediately. For instance, one of the first times Weyh used the camera, he saw from 60 yards away that a contact on a gang-operated switch for the transmission line feeding the station was overheating. These switches are not owned by ACEC, so Weyh contacted the co-op's supplier, American Transmission Company, and suggested they check it out on their next maintenance cycle.

As he scans the rest of the substation, he specifically follows the circuit as it comes from the transmission line. He scans another gang-switch within the station—its fuses and contacts. He scans the high-side insulators (arrestors) and the high-side bushings on the transformer. "Right now," he says, "I am monitoring a bushing in one substation that is running about 40 °F higher than similar bushings under the same conditions. We're keeping a close eye on that situation and trying to figure out when we can plan an outage and take care of the problem."

Next, Weyh inspects the substation's bus work, which has bypass switches that sometimes cause problems. At one substation, the technical services team used a visible-light digital camera in addition to the thermal imager to find the root cause of a problem with a bypass switch. A visible-light image revealed that the bus work did not have any allowance in it for contracting during the cold winter months. So, at that time of year, the bus work distorts the problematic bypass switch, causing the problem. "Again, it's something we will schedule and take care of," Weyh says.

Finally, the team leader uses the infrared imager to scan the regulators, the low voltage-bus and the recloser for each circuit that goes out of the substation.

Every quarter, Weyh performs inspections like that just described on every ACEC substation.

Power lines. Each substation has three to five circuits that vary from three to 15 miles in length. These Weyh checks on three-year cycles: "I patrol a substation's three-phase circuits and any of the larger single-phase circuits off those. I use the infrared camera to inspect pole to pole on the overhead lines."

On underground lines, there are cabinets every quarter of a mile to give service personnel access to elbows (connecting devices). Weyh opens each cabinet and performs a physical and infrared check for overheating. "In the past," he says, "we've had elbows burn up and destroy cabinets. Then, service personnel had to cut up and splice the cable. Now, with the IR camera, we can go out and look for overheating connections and replace them before they fail and destroy cabinets."

Also, on the longest three-phase lines are the 35 regulators mentioned earlier. These get inspected twice a year along with the associated MOV arrestors and bypass switches.

Key accounts. Weyh considers seven of the co-op's members to be key accounts. These, he inspects twice a year, scanning all of the ACEC-owned facilities on each site. The largest, the chicken processing plant, has a complete substation dedicated to it, and it has dozens of the utility's transformers on site—eleven 2000 kVA units plus numerous other small ones.

"It pays to go through there a couple of times a year and check all of the elbow connections," Weyh says. He explains that every transformer has an elbow connection for an underground cable. Also, there are switches on the system to be checked. They support loop feeds that offer alternatives designed to keep the plant operating when electrical service work is required.

"There is a lot of investment in that facility," Weyh notes. "If we can head off damage, we have done our job." For example, a couple of years ago, when he was going through the plant with the IR camera, he found overheating where an elbow plugs into a bushing well that's screwed onto a stud bolt on a transformer. As a result, the utility scheduled an outage for the weekend. Sure enough, the stud was nearly twisted off. It was replaced, but Weyh conjectures that had it failed under load, it probably would have destroyed the transformer.

Taking a thermal image of this pole top located on a dairy farm made it easy to see that there was a problem.

Dairy farms. When he began his work as a technical services team leader, Weyh's principal job was inspecting dairy farms for stray voltage, and that's still part of his job. Today, he uses the infrared camera as a tool in those inspections. "We have several hundred dairy farms on our system, and I try to get out to each of them at least once a year and look at their equipment and facilities," he says. "There often is a pole-top disconnect in the middle of a farm that feeds out to all of the buildings. I can quickly scan it with the infrared camera and see if there is a problem."

To underscore the fact that most utility problems are easy to spot, Weyh reports on the inspection of one farm pole where he used the infrared camera to determine there was a problem even though the actual temperature of the pole top was outside the calibrated range of the instrument. He notified the co-op member, who contacted an electrician and scheduled repairs for the following week. Unfortunately, the pole top burned up before repairs could be made.

Problems and pitfalls

Asked what on-the-job problems he encounters while doing thermography at ACEC, Weyh mentions the following:

Difficulty doing trending. In most predictive maintenance programs, it pays to record the condition of equipment at regular intervals to determine when an asset is trending toward failure. Weyh points out that trending is very difficult for a utility using thermography, especially a utility in the northern U.S. "Yesterday (in June), I was checking equipment and it was 80 °F outside," he explains. "In December, I might be checking the same equipment, and it could be 30 °F or 10 °F. The temperature differences at different times of year make it difficult to get baseline information. So, I rely more on the temperature of a similar object under the same conditions (load) and then look for that temperature rise."

False positives due to ambient heat. Hot weather is a factor even when one uses an IR camera only for comparisons of like objects. Weyh notes that when he opens up a transformer, for example, and it's 80 °F outside, the inside is more than 100 °F. He explains that then he must be careful and ask himself, "Is this elbow warmer than that one because it's overheating or because of convective heating given its location in the transformer?"

False positives due to low emissivity. Weyh says that this is the most difficult problem he has encountered, e.g., shiny busbars. He says that by changing positions he can often determine if the component is reflecting some other heat source or some other cold source. A long-term solution is to apply a small piece of thermal-conducting, high-emissivity material—e.g., black rubber tape or flat black paint—to the component's surface.

Inaccessibility due to wildlife guards. Weyh reveals that some of the co-op's substations have experienced "animal problems." As a result, protection has been installed over the bushings. These protectors make it impossible to see the bushings and, therefore, make it impossible to get IR images of them. While there are transparent guards on the market that would allow thermography, ACEC has not acquired any. So, Weyh takes an indirect approach to inspecting these bushings. He concentrates on the conductors coming out of the bushings to determine if heat might be emanating from the bushings.

Insufficient loading on a circuit. It's best to inspect circuits when they are at least 40 percent loaded, but Weyh cannot always know what loading is on a circuit. He explains that he tries to inspect circuits during their peak seasons, noting that some substations are peaked during the summer and some during the winter. He says, "We lay out our inspection schedule based on that, but irrigation wells, for example, only run at night. Still, if an irrigation operation is having problems, I can go out there, have them fire up their pumps and check things with the camera."

Asked to sum up his experience with a thermal imager, Weyh says, "It has been a good tool. My thoughts are that eventually we are going to catch up, and I'm not going to be finding as many problems." Then he laughingly adds, "Hopefully, I'll work myself out of a job," but quickly notes, "No, the camera will always have a use here."

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