

## Electrical inspections using thermal imaging

### Application Note

By Jim White, Shermco Industries, for Fluke

While many electrical problems are mistakenly blamed on “loose electrical connections and terminals,” sometimes they really are the problem. Loose connections do result in higher resistances. High resistance connections do create heat, which is one of the biggest causes of electrical fires. If the connection is very loose, you can even see charred or melted thermoplastic insulation on the conductors with the naked eye. But not always.

When terminals are loose and under load, arcing can take place inside the threads, causing pitting that can't be seen by visual inspection. When the terminal set screw is retightened, it does not compress the conductor and only seats itself at the point where the damaged threads are. Even though the set screw is now tight, the conductor is still loose in the terminal and overheating continues.

Infrared thermal inspections can find this type of defect reliably. Figure 1 is an example of a molded-case circuit breaker terminal that shows severe overheating. The tested spot is marked by a “cross” and the temperature difference is over 110 °C. NETA (the InterNational Electrical Testing Association) provides industry-accepted recommendations for action points for thermal imaging (see page 3).



Inspection of lighting control circuits with a Fluke Ti25 Thermal Imager and appropriate PPE.

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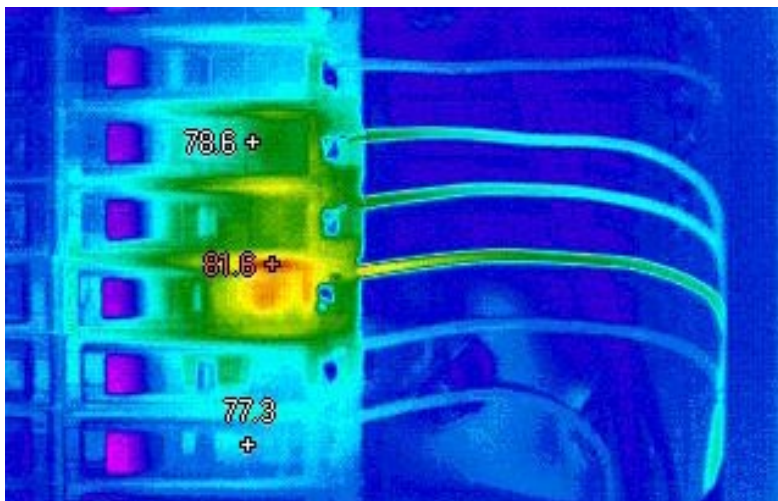


Figure 1. Thermal inspection of a molded-case circuit breaker terminal.

Another area of concern in circuit breakers and switches is high-contact resistance, caused by wear of the contact surfaces, improper lubrication of the contact movable joint or misadjustment. As contacts open and close, especially during fault conditions, the contact faces are eroded. This material is sprayed into the arc chutes, along with carbon and other arc by-products.

Insufficient contact pressure is often the result of wear and erosion, although improperly adjusted contacts can also have excessive contact pressure. Many technicians seem to think that more contact pressure means better breaker operation. Just the opposite is true.

Figure 2a, found in a breaker at Shermco's circuit breaker rebuild facility, shows a circuit breaker contact face that cracked due

to excessive pressure. Figure 2b shows the same type of contact after the breaker tried to interrupt a fault with a cracked face. The entire contact vaporized.

This circuit breaker suffered a "restrike", where it couldn't safely clear a fault, and the next breaker upstream had to open. As more upstream breakers open, larger portions of the electrical system are de-energized. This is often referred to as "cascading."

Figure 3 shows a switch with high contact resistance. Later inspection found that the operating mechanism was experiencing mechanical binding. This fairly common defect can sometime weld the contacts together (Figure 4). Both situations are extremely hazardous. An overheating contact assembly (Figure 3) could cause a fire or fail when opened or closed, and a welded contact (Figure 4) can't open. If the welded phase won't clear during fault conditions, it could result in an explosion. During normal operation, the welded phase would remain energized.

Proper procedures for putting equipment in an Electrically-Safe Work Condition (as required by OSHA and the NFPA 70E) would find this problem, but an electrical worker who was not so careful could be shocked, resulting in injury or fatality.



Figure 3. Improper contact pressure.



Figure 4. Molded-case circuit breaker with welded contact.

## Summary

Electrical and mechanical equipment will fail. The question we can't answer is, "When will it fail?" Often, deterioration produces warning signs that can be identified by a thermal imager, before the device fails. Properly trained and certified infrared thermographers can locate problems before they cause major issues. Be sure to work with reputable companies with known, good reputations.

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Figure 2a. Cracked contact face.



Figure 2b. Cracked face after fault.

## Thermographic survey suggested actions based on temperature rise

NETA (the InterNational Electrical Testing Association) provides guidelines for thermal inspections of electrical equipment in the new ANSI/NETA MTS-2007 and, for newly-installed equipment, ATS-07. MTS stands for "Maintenance Testing Specifications", while ATS is "Acceptance Testing Specifications". These guidelines are based on differences in temperature from one phase conductor or component to another. Recommended action is dependent on the difference in the temperatures, as illustrated in Table 100.18 from the ANSI/MTS-2007, below.

Temperature specifications vary depending on the exact type of equipment. Even in the same class of equipment (i.e., cables), there are various temperature ratings. Heating is generally related to the square of the current; therefore, the load

Temperature difference ( $\Delta T$ ) based on comparisons between similar components under similar loading	Temperature difference ( $\Delta T$ ) based on comparisons between component and ambient air temperatures	Recommended action
1 °C to 3 °C	1 °C to 10 °C	Possible deficiency; warrants investigation
4 °C to 15 °C	11 °C to 20 °C	Indicates probable deficiency; repair as time permits
-----	21 °C to 40 °C	Monitor until corrective measures can be accomplished
>15 °C	>40 °C	Major discrepancy; repair immediately

Table 100.18 "Thermographic Survey Suggested Actions Based on Temperature Rise" Courtesy InterNational Electrical Testing Association ANSI/MTS-07

current will have a major impact on  $\Delta T$ . In the absence of consensus standards for  $\Delta T$ , the values in this table will provide reasonable guidelines.

An alternate method of evaluation is the standards-based temperature rating system as discussed in Section 8.9.2, Conducting an IR Thermographic Inspection, Electrical Power Systems Maintenance and Testing by Paul Gill, PE, 1998.

The person performing the electrical inspection must be thoroughly trained and experienced concerning the apparatus and systems being evaluated, as well as knowledgeable of thermographic methodology.

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