Application Paper **AP003001EN** Effective April 2017

Eaton circuit breakers meet or exceed the strict requirements for heat rise from Underwriters Laboratories

UL® requirements for maximum heat rise

Manufacture of circuit breakers is governed by one or more of these standards: UL 489, UL 943, and UL 1699. UL 489 covers overload, endurance, and short circuit (including temperature). UL 943 covers ground fault test requirements. UL 1699 covers arc fault test requirements.

Per UL 489, every circuit breaker must complete an overload (Sequence-X) test to receive UL listing. This test involves opening and closing the circuit breaker at 600% rated current for 50 operations. This exposes the breaker to much higher internal temperatures than are expected under normal usage. Following the overload test, the circuit breakers are tested at 100% rated current and cannot exceed a 50 °C (90 °F) temperature rise at the wire terminal connection in 40 °C (104 °F) open air.

This temperature test may also be performed in an enclosure at 80% rated current and temperature may not exceed 65 °C (117 °F) rise over ambient. This test ensures that the manufactured product has been designed to prevent overheating throughout the lifetime of exposure to heat and arcing.

The plastic housings of the type CH and BR arc fault and ground fault products are molded out of IDI Dielectrite 46-12, a 22% glass-filled thermoset polyester. The heat deflection temperature of Dielectrite 46-12 under a 264 psi load exceeds 260 °C (500 °F) according to the ASTM D-648 test procedure. This means that the ambient temperature within the circuit breaker would need to reach 260 °C (500 °F) before the plastic material would begin to break down structurally.

These circuit breakers have been designed to function both electronically and mechanically at temperatures exceeding 90 °C (194 °F). The UL test procedure was developed such that any listed circuit breaker should not exceed 90 °C (194 °F), measured at the line or load terminal.

These measurements are taken at the load terminal. Homeowners and inspectors do not inspect the load terminal; they feel the cover of the panel and the handle of the breaker. The next section addresses overall expected heat rise in a loadcenter.

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Heat rise of exposed parts

UL 489, paragraph 7.1.4.1.6 states "The maximum temperature on handles, knobs, and other surfaces subject to user contact during normal operation shall not exceed 60 °C (140 °F) on metallic and 85 °C (185 °F) on nonmetallic surfaces."

UL 67, which governs panelboards, is mute on the allowable temperature of the deadfront and cover. Specific components of the panelboard have limits governing their rise above ambient temperature, as stated in Table 19.1, but these limits all apply to current-carrying conductors and the insulation surrounding them.

Material tolerance for heat and mechanical performance

Expected heat rise in normal applications

This section discusses the expected temperature rise we encounter on the cover of the panel or the handle of the circuit breaker. The line terminal or bus bars, as called out above, will not be discussed.

A panel full of non-electronic, standard thermal-magnetic circuit breakers running a heavy load—for instance, above 50% the rating for the main circuit breaker protecting the panel, or 100 A in a 200 A service—is expected to rise 15 °C (27 °F) above ambient temperature.

Eaton AFCI circuit breakers consume less than 1 watt to power up the electronics within the breaker. This additional power consumption, above the contribution from the mechanical components mentioned above, can add another 5–10 °C (9–18 °F) of heat rise above ambient for the system.

Eaton AF/GF circuit breakers consume slightly more than 1 watt to power up their internal electronic components. A panel full of AF/GF breakers might rise 10–20 °C (18–36 °F) above ambient. Given a typical mix of circuit breakers and typical consumption, we expect a 25–30 °C (40–54 °F) heat rise on the hottest part of the exposed panel cover above the ambient temperature.

In a 38 °C (100 °F) garage, it would not be surprising, nor would it be unsafe, to see a panel as warm as 65 °C (150 °F). As demonstrated above, the materials of the circuit breakers are designed and tested to function in much higher temperatures than 65 °C (150 °F).

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