



# Cutler-Hammer

## AFCIs and Heat Rise

Application Data

New Information

## Introduction

Arc Fault Circuit Interrupter (AFCI) breakers are listed to UL® 489 and UL 1699. UL 489 covers overload, endurance and short circuit (including temperature). UL 1699 covers arc fault test requirements.

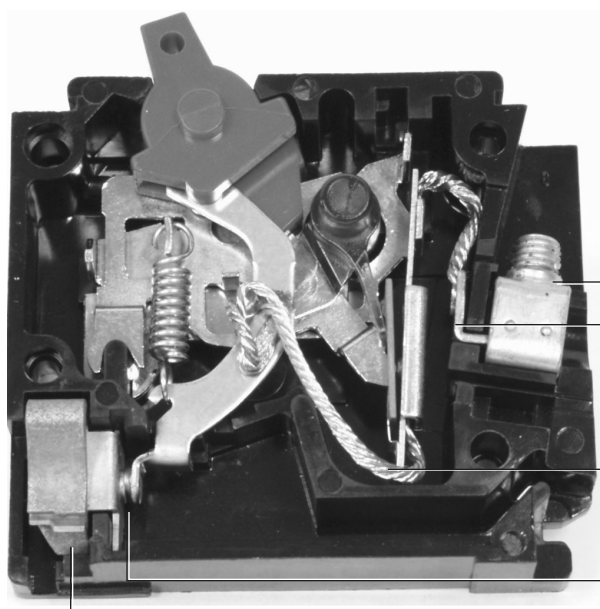
Per UL standard 489 for molded case circuit breakers, the breaker is required to pass an overload test (50 operations at 600% rated current, not less than 150 amperes) followed by 100% rated current in open air with a temperature not to exceed 50°C rise over ambient at both line and load terminals.

This temperature test may also be performed in an enclosure at 80% rated current and temperature not to exceed 65°C rise over ambient. (The handle shall not exceed 60°C.)

What this means is that in a loadcenter with a 70°F ambient temperature, the temperature rise can be as high as 187°F and still meet UL operating parameters for the breaker. While the breaker functions properly to this temperature, it will normally be in the 80 – 120°F range due to the electronics in the breaker.

The heat from a normal thermal/magnetic circuit breaker is generated by five sources. See photo on **Page 2**.





Resistance of the load terminal connection

Resistance of the bimetal

Resistance of the wire braids that carries current to/from the self-heated bimetal

Resistance across the breaker's contacts

Resistance at the breaker bus bar connection (in a residential application this is a plug-in connection; commercial breakers have a bolt-on connection).

**Standard Circuit Breaker with Case Opened**

You will notice that all of the metal current-carrying components are un-insulated, as the breaker case is an insulator. The case is made of a very high temperature thermal-set plastic material, as the case must survive the extreme temperatures that occur during the interruption of short circuit currents as high as 10 kA. The circuit breaker designer and UL are not concerned about the temperature of the internal metal parts or the case, but rather the temperature of the load terminal. The temperature of the load terminal determines the maximum temperature of the insulation on the wire connected to the terminal. On residential circuit breakers, the temperature rise of this terminal must be 50°C or less above ambient when

carrying rated current, or 65°C or less above ambient in an enclosure.

The AFCI construction differs from the standard breaker shown above, as it must not only house a breaker mechanism but also circuitry to perform the arc sensing and interruption function. This circuitry is located near the load terminals. It has additional conductors that carry both the load and neutral currents through a ground-sensing differential transformer. These conductors have resistance and thus contribute to a slight increase in temperature. The biggest temperature rise effect comes from the bimetal adjustment screw that is located under the push-to-test button adjacent to the hot spot. This screw runs at the

bimetal temperature and can be very hot. The internal construction of the AFCI breaker, including electronics, is nearly identical to our GFCI breaker constructions. The temperatures are essentially the same. We've been selling these breakers for nearly 30 years with no issues.

Due to the fact that AFCIs are becoming more prevalent in consumers' homes, there is more potential for this to be perceived as a problem. By being knowledgeable about why there is greater heat rise in electronic breakers, you can help prevent these misconceptions and communicate why this occurs.

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