Circuit Breaker Operating Temperatures

Introduction

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Understanding acceptable circuit breaker operating temperatures will help avoid unnecessary replacements and returns. A circuit breaker that is warm to the touch, or too hot to touch, is normally within acceptable operating temperatures. Therefore, it is important to obtain the temperature reading on the circuit breaker rather than going by touch. Non-metallic handles, knobs, and other user contact surfaces are allowed to reach a maximum temperature of 185ºF (85ºC) per Underwriters Laboratories® (UL®).

Acceptable Operating Temperatures are Defined by UL 489

The acceptable operating temperature of a circuit breaker is defined by UL in the UL489 Standard (reference Jan. 2013), which is summarized in the table below.

Summary of Allowable Temperature Rise and Maximums for a Standard Rated Circuit Breaker

NOTE: Circuit breakers are usually calibrated for 104ºF (40ºC) ambient.

Surface:	Allowable Temperature Rise above Ambient	Temperature Maximum at a 104ºF (40ºC) ambient
Termination on standard rated circuit breaker	90ºF (50ºC)	194ºF (90ºC)
Termination on 100% rated circuit breaker	108ºF (60ºC)	212ºF (100ºC)
Handles, knobs, other user contact surfaces–metallic	N/A	140ºF (60ºC) Maximum
Handles, knobs, other user contact surfaces–nonmetallic	**N/A**	**185ºF (85ºC) Maximum**

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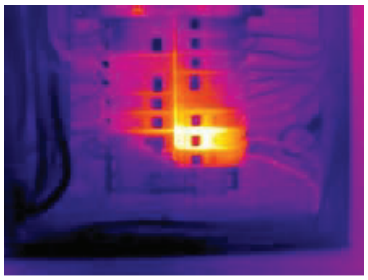
Terminations for standard rated circuit breakers: Paragraph 7.1.4.2.2, paraphrased, says the temperature rise on the termination (cable or bus bar) shall not exceed 90º F (50º C).

Terminations for 100% rated circuit breakers: Paragraph 7.1.4.3.3, paraphrased, says the temperature rise on the termination (cable or bus bar) shall not exceed 108º F (60º C).

Handles, knobs, and other user surfaces: Paragraph 7.1.4.1.6 says the maximum temperature on handles, knobs, and other surfaces subject to user contact during normal operation shall not exceed 140ºF (60ºC) on metallic and 185ºF (85ºC) on nonmetallic surfaces.

Heat Generation

Infrared Scan showing Normal Temperatures of Circuit Breakers in a Load Center



NOTE: Temperatures vary with load characteristics.

Where does the heat come from, and how is it calculated? The normal heat generators inside the circuit breaker are the main contacts, bi-metal for tripping, electronics and power supplies, causing the circuit breaker body to increase in temperature. The body of the circuit breaker can be hotter than the terminations, since the load wires act as heat sinks (see Figure at left). Each circuit breaker family or frame will have its own heating characteristics due to different designs, so not all circuit breakers run at the same temperature.

The amount of heat a circuit breaker generates from pole resistance (watts loss) can be calculated with the following formula: P = I^2 x R, where:

P = Watts loss per pole, in watts

I = Load current in amperes

R = Pole resistance in ohms.

The pole resistance (in micro ohms) for many circuit breakers can be found in the Field Testing and Maintenance Guide 0600IB1201.

Commercial Example: Refer to table titled Maximum Micro-Ohms Per Pole in the Field Testing and Maintenance Guide 0600IB1201 of the pole resistance PowerPacT™ H-Frame 15 A circuit breaker is 35,000 micro ohms. Convert that to 0.035 Ohms. Now using the formula:
P = I^2 x R, P = 15 A x 15 A x 0.035 Ohms = 7.9 watts per pole.

The circuit breaker in this example generates or loses 7.9 watts per pole. For a three-pole circuit breaker 7.9 watt x 3 poles = 23.6 watts.

Residential Example: the QO120CAFI combination arc fault circuit breaker generates approximately 2.2 W from resistance and 0.8 W from the on-board electronics, for a total of 3 W. 3 W is considerably lower than the heat generated by the home wiring, for example, a 20 A load through fifty feet of #12 AWG Cu wire generates approximately 32 watts, due to resistance (1.6 Ohms per 1000 ft.). The wire stays cooler because it dissipates the heat over the length of the wire. Compared to the home wiring, the circuit breakers generate very little “heat”, even though the circuit breaker temperature is higher, since the heat is more concentrated.

Primary Injection Testing



If a circuit breaker is operating within the temperature rise and maximum values in the previous table, then the circuit breaker should be operating normally. If one thinks that the circuit breaker is suspect and is concerned that the circuit breaker may nuisance trip, then it is recommended that Square D™ Field Services be employed to run a primary injection test on the circuit breaker to determine whether or not the circuit breaker is performing per its characteristic tripping curve. Instruction Bulletin 0600IB1201 Field Testing and Maintenance Guide is a great reference for visual inspection, preventative maintenance, and performance testing of thermal magnetic and MicroLogic™ electronic trip circuit breakers.

Thermographic Inspection

⚠ DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E, CSA Z462, or NOM-029-STPS.
- This equipment must only be installed and serviced by qualified electrical personnel.
- Only qualified electrical workers with training and experience on low-voltage circuits should perform thermographic inspections. These workers must understand the hazards involved in working with or near low-voltage equipment. Perform such work only after reading this complete set of instructions.
- Replace all devices, doors and covers before turning on power to this equipment.

Failure to follow these instructions will result in death or serious injury.

Infrared thermographic inspection techniques may be useful in evaluating the operating condition of circuit breakers and terminations. Comparison to stored infrared thermographic images may be useful for the preventative maintenance of circuit breakers and end-use equipment. The actual amount of heat emitted is a function of both load current and ambient conditions. Interpretation of infrared images requires experience and training in this type of inspection.

Allow initially energized circuit breakers at least three hours to reach operating temperature. Compare the thermographic images of individual circuit breakers to previously stored images of the same circuit breakers.

Additional Information

For more information concerning Square D circuit breakers, refer to the appropriate instruction manual. These manuals contain installation instructions, mounting information, safety features, wiring diagrams, and troubleshooting charts for specific circuit breakers.