Data Bulletin

Determining Current Carrying Capacity in Special Applications

INTRODUCTION

To meet the requirements of Underwriters Laboratories Standard 489, molded case circuit breakers are designed, built, and calibrated for use on 60 Hz ac systems in a 40°C (104°F) ambient temperature. Time/current characteristic trip curves are drawn from actual test data that meets UL 489 testing requirements.

When applied at ambient temperatures other than 40°C, at frequencies other than 60 Hz, on dc systems, or in other extreme conditions, the performance characteristics of the circuit breaker may be affected. In these cases, the current carrying capacity and/or trip characteristics of the circuit breaker may vary. This bulletin explains how to correctly apply circuit breakers under these special conditions.

RERATING FOR AMBIENT CONDITIONS

Ambient temperature is defined as the temperature of the air surrounding a circuit breaker. Since thermal-magnetic circuit breakers are temperature-sensitive devices, their rated continuous current carrying capacity is based on a UL specified 40°C (104°F) calibration temperature. When applied at temperature other than 40°C, it is necessary to determine a circuit breaker's actual current carrying capacity under this condition.

Square D circuit breakers can be applied in ambient temperatures within the range of -10°C to 60°C (14°F to 140°F). This document provides guidelines to follow when adjusting for ambient conditions.

WHEN IS AMBIENT RERATING NECESSARY?

By properly applying an appropriate ambient rerating curve (see Figs. 4–27 on pages 5–12), a circuit breaker's current carrying capacity at various temperatures can be predicted.

Follow the procedure outlined in this bulletin and select cable per NEC Table 310-16, taking ambient temperature into account.

Thermal-Magnetic Circuit Breakers

- Ambient Temperatures Between 25°C and 40°C (77°F and 104°F):

  No rerating is necessary.

- Ambient Temperatures Between -10°C and 24°C (14°F and 75°F):

  Circuit breakers operating within this ambient temperature range will carry more than their continuous current rating without tripping.

  Nuisance tripping will not be a problem. However, if closer protection of the equipment and conductor is required, the increased current carrying capacity of the circuit breaker at the lower ambient temperature should be taken into consideration.

- Ambient Temperatures Between 41°C and 60°C (106°F and 140°F):

  Circuit breakers operating within this ambient temperature range will carry less than rated continuous current and must be carefully selected to prevent nuisance tripping.

Electronic Trip Circuit Breakers

The trip units on Square D electronic trip circuit breakers are ambient-insensitive from -10°C to 60°C (14°F to 140°F). Temperatures outside this range may damage the trip unit's circuitry or other components.

Rerating due to ambient conditions is required on certain circuit breaker frames to prevent overheating of internal circuit breaker components.

Consult Square D Company for appropriate circuit breaker rerating factors and the National Electrical Code (NEC) for derating of conductors.

HOW TO RERATE CIRCUIT BREAKERS FOR AMBIENT CONDITIONS

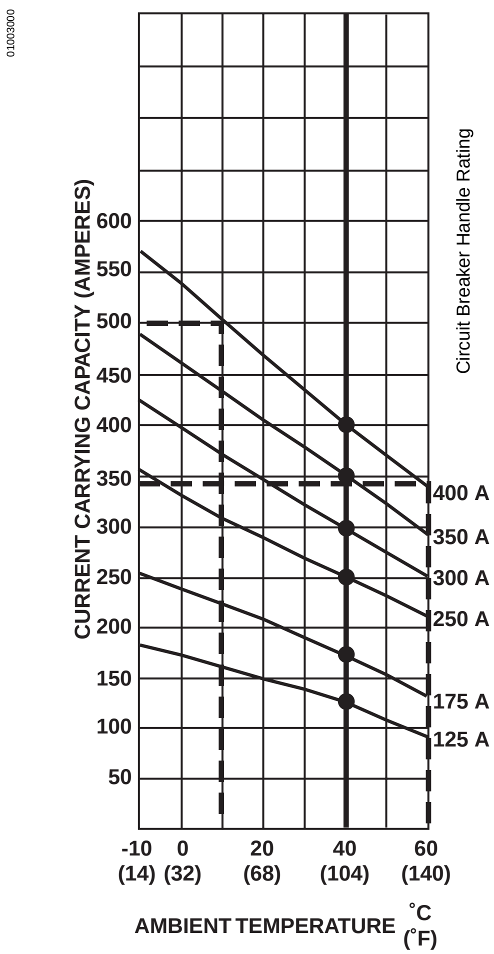

Figure 1: Ambient Rerating Example—LA, LAL Circuit Breakers

To determine the continuous current carrying capacity of a thermal-magnetic circuit breaker at an ambient temperature other than rated ambient temperature (40°C), perform the following steps:

1. Choose the ambient rerating curve for the circuit breaker family involved (see Figs. 4–27 on pages 5–12).
2. Find the curve for the circuit breaker you wish to apply. Note that the curve crosses the 40°C (104°F) ambient temperature line at the circuit breaker's rated continuous current carrying capacity ("Circuit Breaker Handle Rating" on the curve).
3. Follow this curve to the appropriate ambient temperature.
4. Read the adjusted continuous current carrying capacity at this point (on the left axis).
5. Add in any other applicable factors, such as continuous loading, per the NEC requirement discussed below.

For example, Figure 1 shows the ambient rerating curves for a 400 A frame LA circuit breaker. What is the continuous current capacity of a 400 A circuit breaker applied at 40°C (104°F)? At 10°C (50°F)? At 60°C (140°F)?

By finding 40°C on the horizontal axis and reading up to the 400 A curve, you find that the circuit breaker will carry 400 A, which is its rated current carrying capacity. If the circuit breaker will be used on a continuous load (defined as three hours or more), Section 210-20(a) of the 1999 NEC requires that loading not exceed 80% of the rating. Here, 400 A x .80 = 320 A.

As explained in Section 210-20(a) of the NEC:

> "Where a branch circuit supplies continuous loads or any combination of continuous and noncontinuous loads, the rating of the overcurrent device shall not be less than the noncontinuous load plus 125 percent of the continuous load.
>
> *"Exception: Where the assembly, including the overcurrent devices protecting the branch circuit(s), is listed for operation at 100 percent of its rating, the ampere rating of the overcurrent device shall be permitted to be not less than the sum of the continuous load plus the noncontinuous load."*

If you locate 10°C (50°F) on the horizontal axis and read up to the 400 A curve, you find that the circuit breaker will carry 500 A. Again, if the circuit is used on a continuous load, it must be applied at 80% of its rating. Here, this is 500 A x .80 = 400 A.

Finally, if you apply the circuit breaker at 60°C, reading the curve will tell you that the circuit breaker will carry 335 A. Used on a continuous load, the circuit breaker must be applied at 80% of its rating. Here, this is 335 A x .80 = 272 A.

RERATING FOR HIGH FREQUENCY

Application of thermal-magnetic circuit breakers at frequencies above 60 Hz requires that special consideration be given to the effects of high frequency on the circuit breaker characteristics. Thermal and magnetic operations must be treated separately.

Thermal Performance

At frequencies below 60 Hz, the thermal rerating of thermal-magnetic circuit breakers is negligible. However, at frequencies above 60 Hz, thermal rerating is required.

EXAMPLE

When applying a 200 ampere KA circuit breaker on a 400 Hz system, the circuit breaker's current carrying capacity will be as follows:

- Non-continuous Loads (less than three hours): Using Figure 2, the KA circuit breaker should be applied at .92 of rating, or 184 amperes.
- Continuous Loads (three hours of more): NEC Article 210-20(a) requires that standard circuit breaker loading does not exceed 80% of the circuit breaker's rating when used for continuous loads. (Unless the assembly is rated for operation at 100% of rating.)
  — Therefore, the current carrying capacity of a 200 ampere KA circuit breaker operating under continuous load at 400 Hz would be 200 A x .92 x .80 = 147 A.

One of the most common high frequency applications is at 400 Hz. Figure 2 indicates the thermal rerating multiplier to be used with each circuit breaker family when applied on 400 Hz systems.

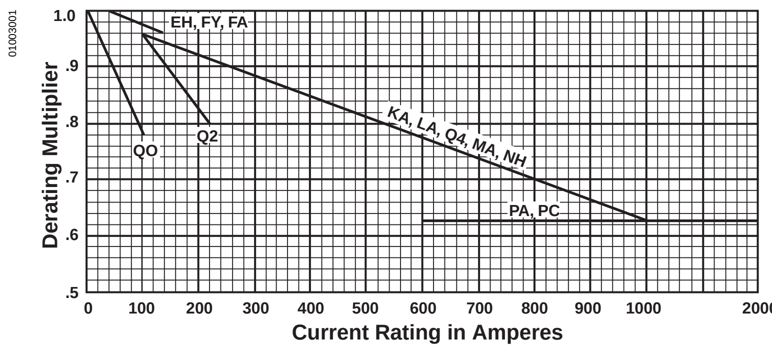

Figure 2: 400 Hz Thermal Rerating Multiplier

Magnetic Performance

At frequencies above 60 Hz, tests indicate that it takes more current to magnetically trip a circuit breaker than is required at 60 Hz. Figure 3 shows the multipliers of 60 Hz current that it takes to instantaneously trip a circuit breaker when applied at various frequencies.

EXAMPLE

At 60 Hz, it takes 1000 amperes (nominal) to instantaneously trip a 200 ampere KA circuit breaker at its low setting. At 400 Hz, it takes 2600 amperes (2.6 multiples) to instantaneously trip the same circuit breaker.

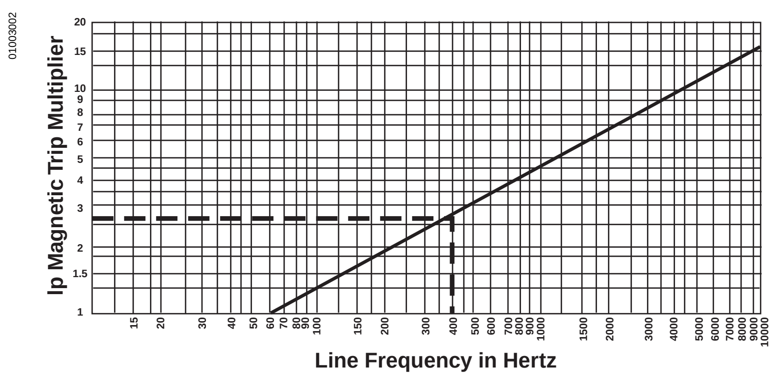

Figure 3: High Frequency Magnetic Trip Multiplier

EXAMPLE

Unless specifically marked, on 400 Hz systems the interrupting capacity of Square D circuit breakers is reduced to 1/10 of the 60 Hz interrupting capacity. This is generally acceptable because most 400 Hz applications are generator systems with a maximum available fault current of 1000 amperes or less.

At frequencies above 60 Hz, the interrupting capacity of thermal-magnetic circuit breakers is less than the 60 Hz interrupting capacity.

RERATING FOR HIGH ALTITUDE

When applying thermal-magnetic circuit breakers at high altitudes, both current and voltage adjustments are required. Current rerating is required because of the reduced cooling effects of the thinner air present in high altitude applications. Voltage rerating is necessary because of the reduced dielectric strength of the air.

The following values are taken from the ANSI Standards C37-13-1981 and C37-14-1979 and should be used when aplying Square D circuit breakers at high altitudes:

	Altitude Multiplier	
Altitude	**Current**	**Voltage**
0–6600 ft. (0–2011 m)	1	1
6600–8500 ft. (2011–2591 m)	0.99	0.95
8500–13000 ft. (2591–3962 m)	0.96	0.80

EXAMPLE

A 100 A, 600 Vac, FA circuit breaker is to be applied at an altitude of 10,000 feet. Its current carrying capacity must be adjusted to 0.96 of rated current (100 x 0.96 = 96 amperes) and voltage rating adjusted to 0.80 (600 x 0.80 = 480 Vac).

Therefore, when this circuit breaker is applied at 10,000 feet, it should be considered a 96 A, 480 Vac circuit breaker.

RERATING FOR DIRECT CURRENT

Trip curves provide complete time/current characteristics of circuit breakers when applied on ac systems only. When applying Square D thermal-magnetic circuit breakers, 1000 A frame or less, on dc systems, the circuit breaker's thermal characteristics remain unchanged. The magnetic portion of the curve, on the other hand, requires a multiplier to determine an equivalent dc trip range. This is necessary because time-current curves are drawn using root-mean-square (RMS) values of arc current, while dc current is measured in peak amperes.

The table below lists this multiplier for the magnetic portion of each family of thermal-magnetic circuit breakers:

Circuit Breaker Family	**Continuous Current Multiplier**
QO	1.2
Q1	1.3
Q2	1.35
EH	1.3
FA/FH	1.15
KA/KH	HI: 1.15, LO: 1.3
LA/LH	HI: 1.2, LO: 1.4
MA/MH	HI; 1.1, LO: 1.2

Thermal-magnetic circuit breakers above 1000 A frame and all electronic trip circuit breakers—unless specifically marked for use on dc systems—utilize current transformers in the current detection circuitry and can not be used on dc systems.

For interrupting ratings in dc applications, please refer to Square D data bulletin 0600DB0104, "DC-rated Circuit Breakers."

EXAMPLE

Determine the equivalent dc magnetic trip level for a 200 ampere KA circuit breaker:

AC HI Value = 2000 A ± 20%
DC HI Value = 2000 A x 1.15 = 2300 A ± 20%

AC LO Value = 1000 A ± 25%
DC LO value = 1000 A x 1.3 = 1300 A ± 25%

AMBIENT RERATING CURVES

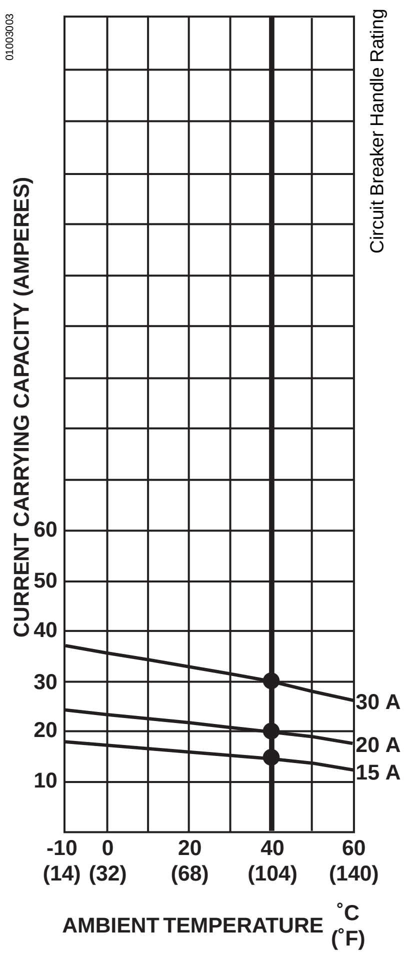

Figure 4: QOT Circuit Breakers

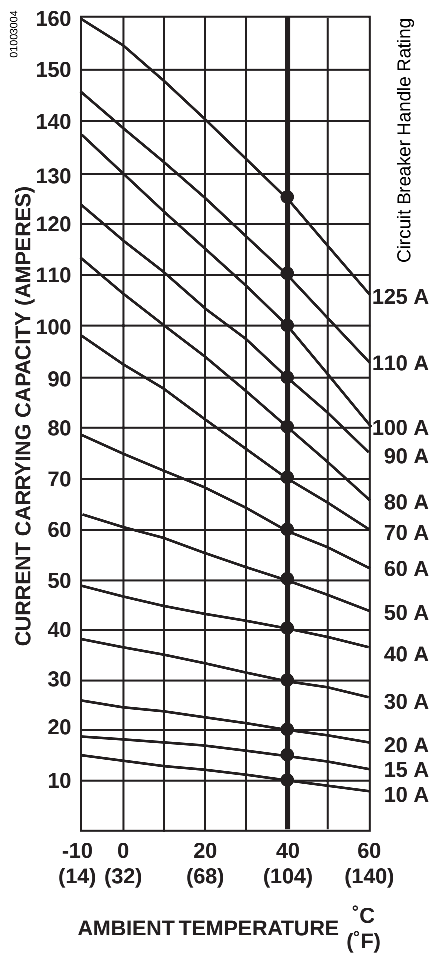

Figure 5: QO, QOB Circuit Breakers

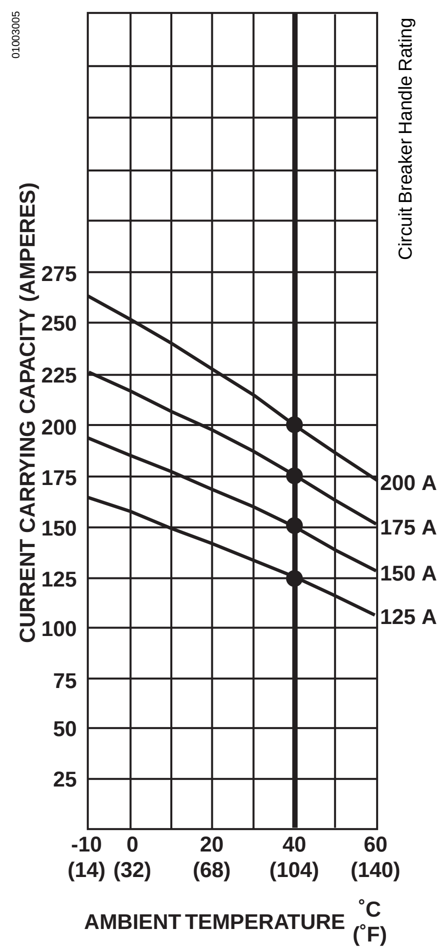

Figure 6: QE Circuit Breakers

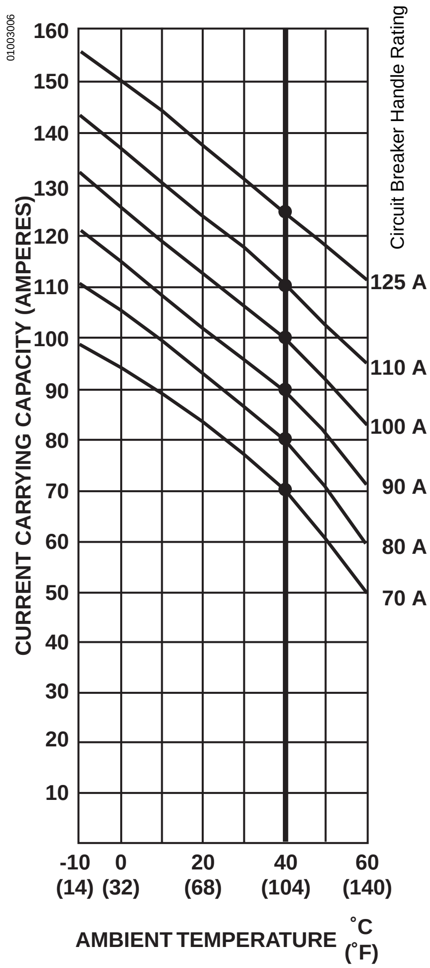

Figure 7: QOM1 Circuit Breakers

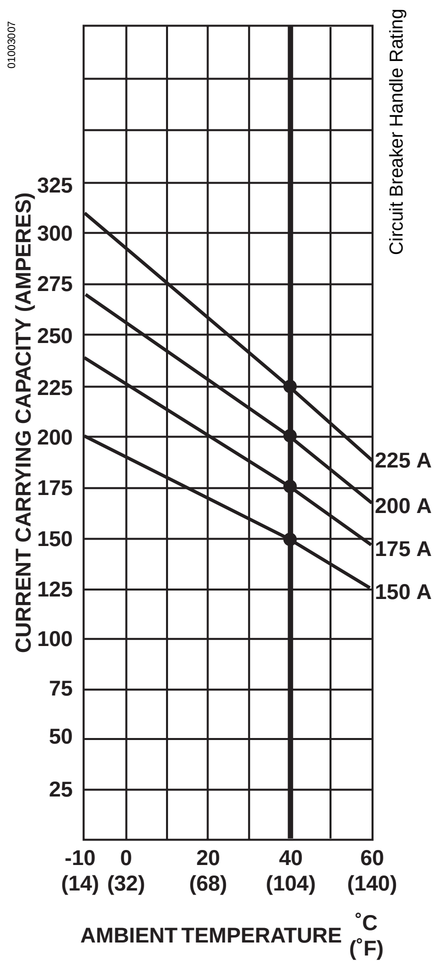

Figure 8: QOM2 Circuit Breakers

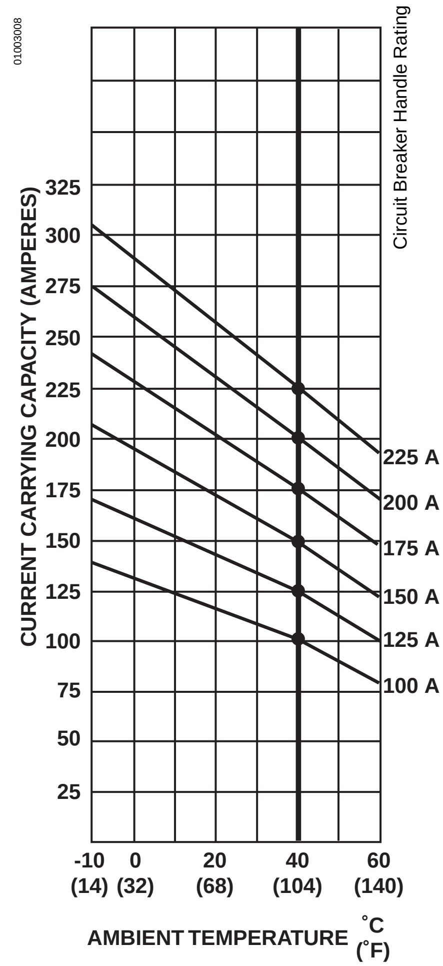

Figure 9: Q2 Circuit Breakers

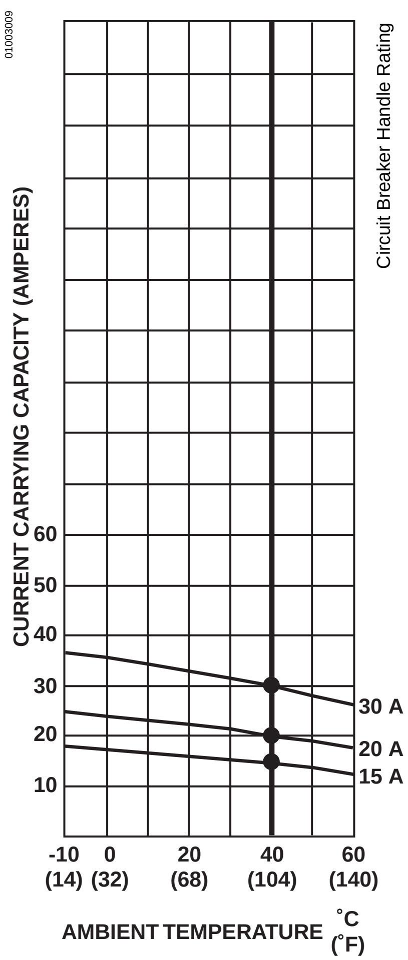

Figure 10: FY Circuit Breakers

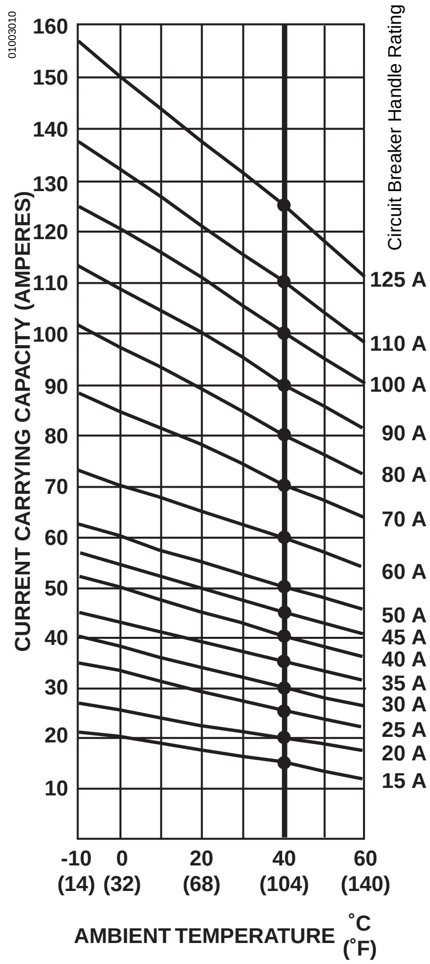

Figure 11: EDB, EGB, EJB Circuit Breakers

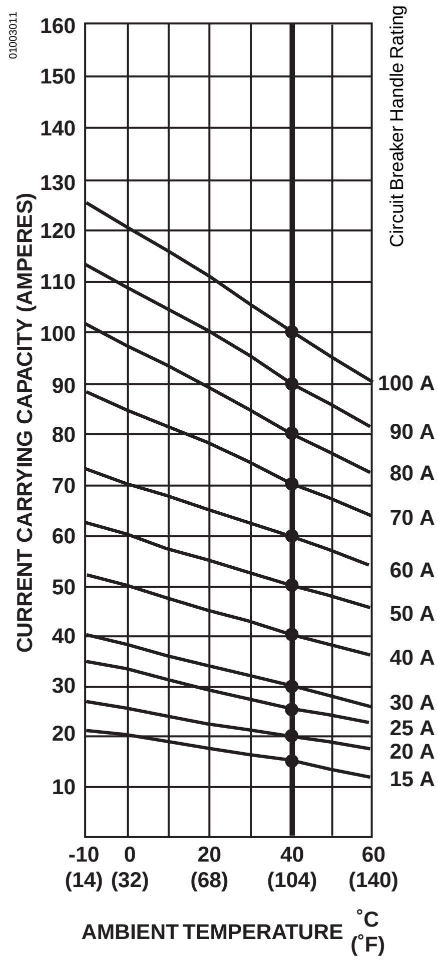

Figure 12: EH Circuit Breakers

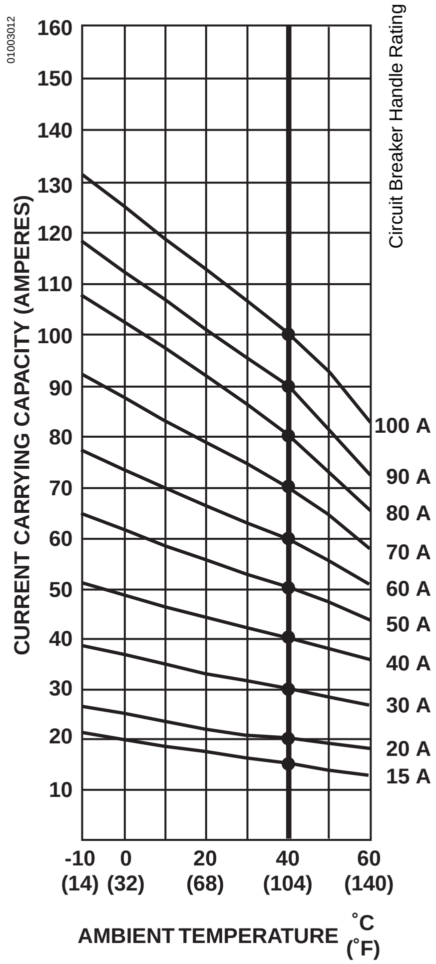

Figure 13: FA Circuit Breakers

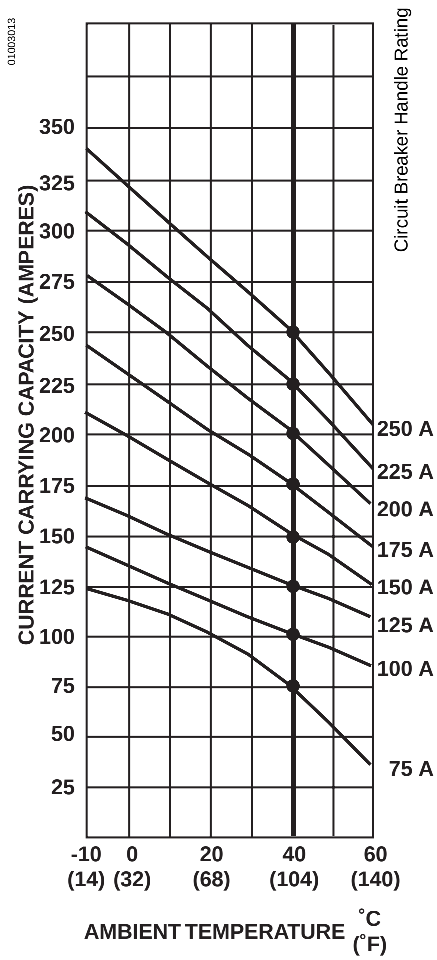

Figure 14: KA Circuit Breakers

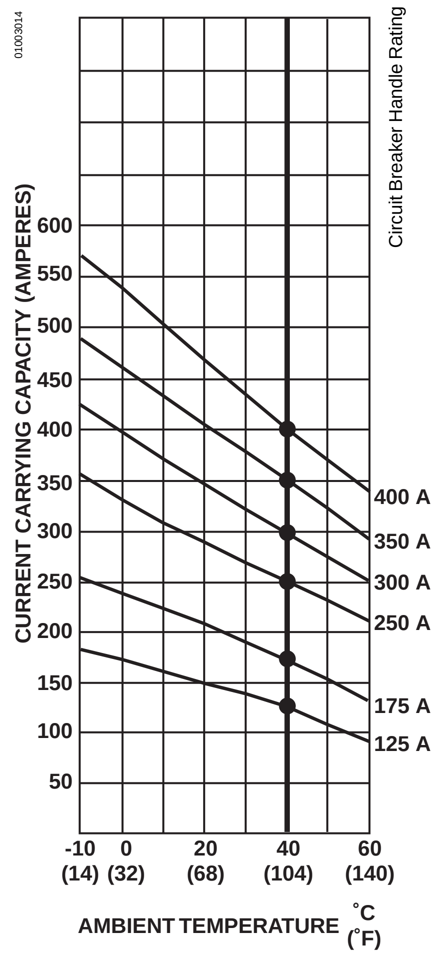

Figure 15: LA Circuit Breakers

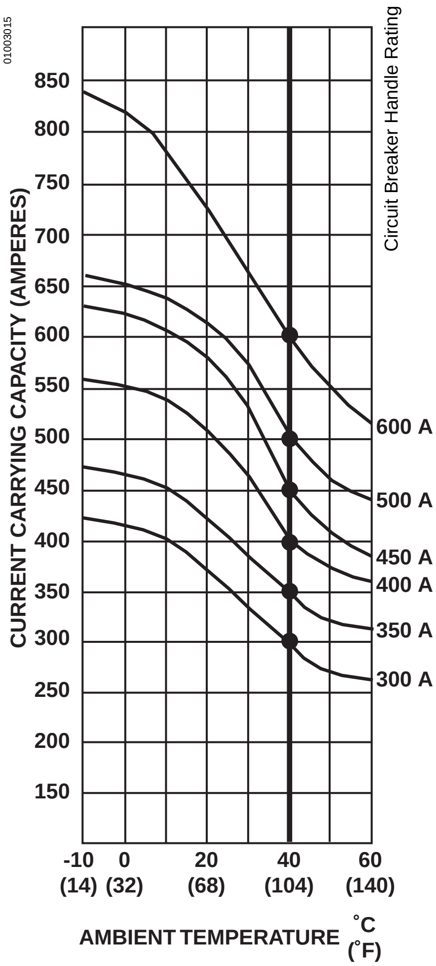

Figure 16: LC Circuit Breakers

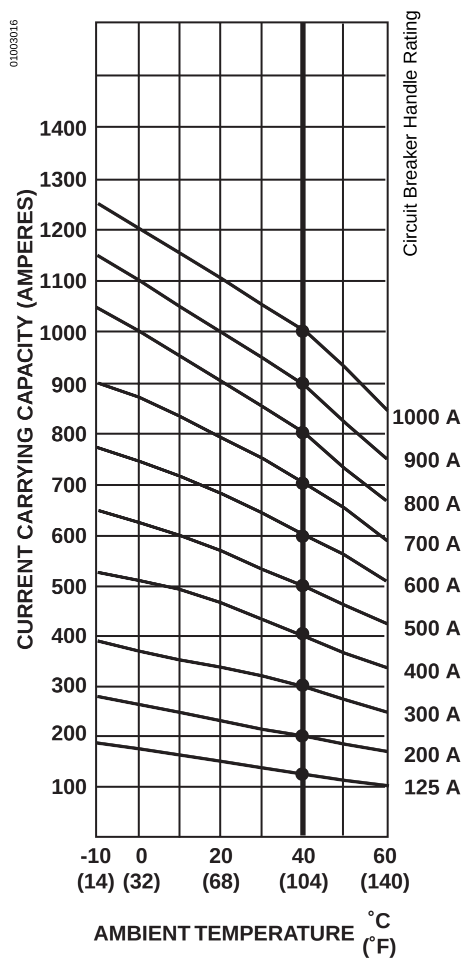

Figure 17: MA Circuit Breakers

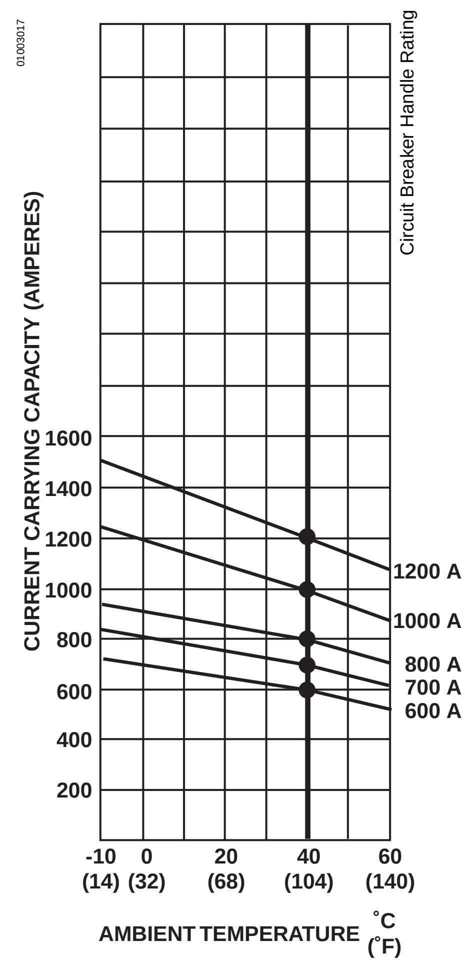

Figure 18: NH Circuit Breakers

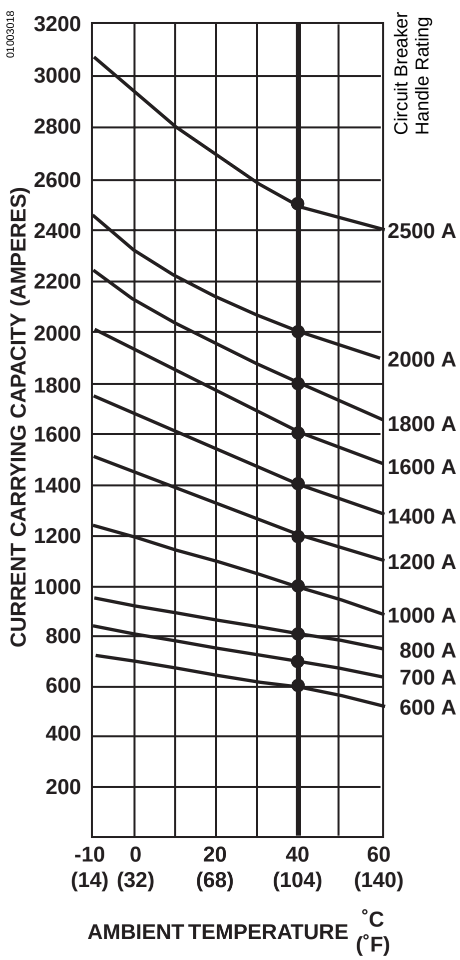

Figure 19: PA Circuit Breakers

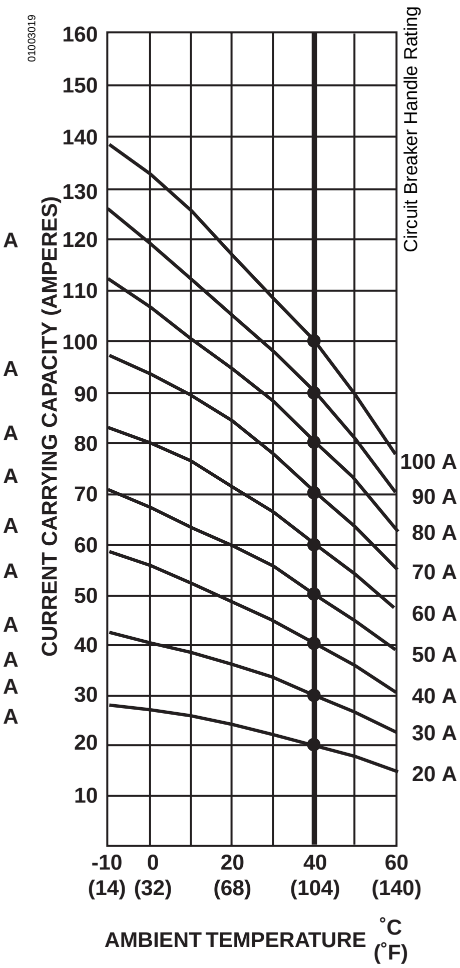

Figure 20: FI Circuit Breakers (manufactured before June 1985)

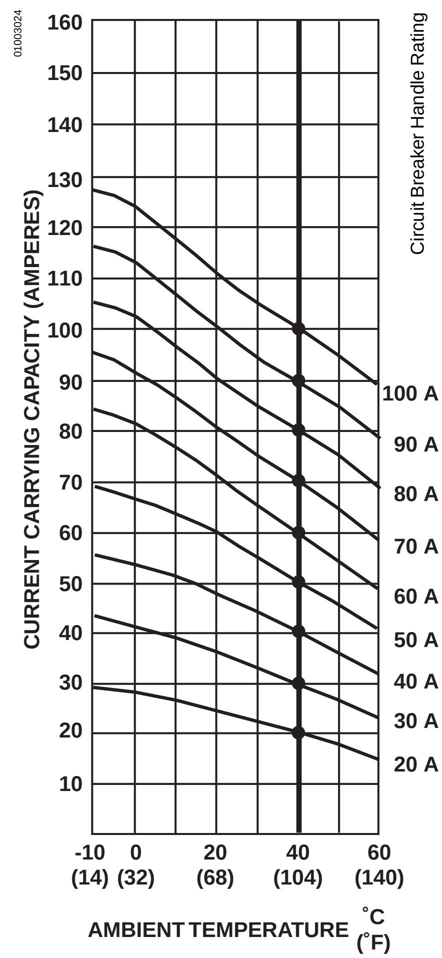

Figure 21: FI 600 V Circuit Breakers (manufactured after June 1985

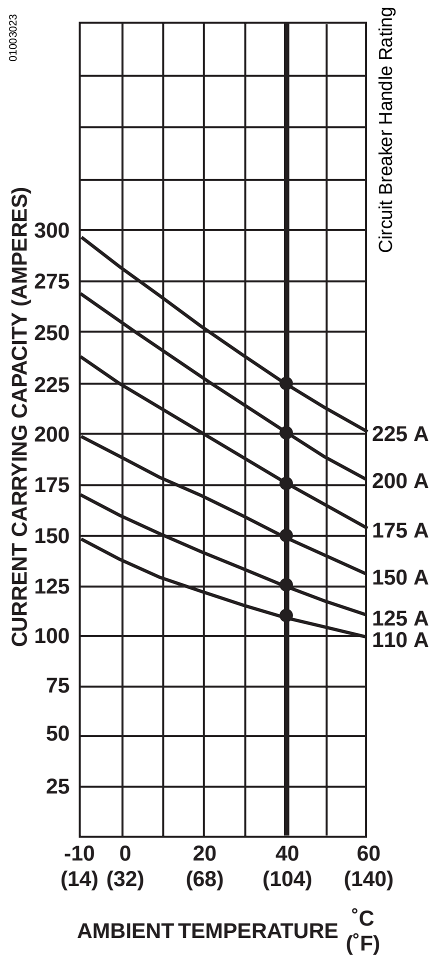

Figure 22: KI Circuit Breakers (manufactured before April 1985)

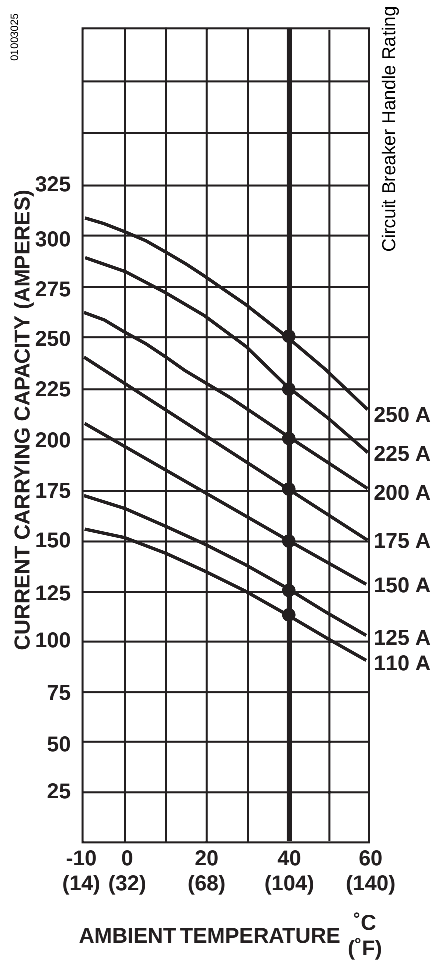

Figure 23: KI 600 V Circuit Breakers (manufactured after April 1985)

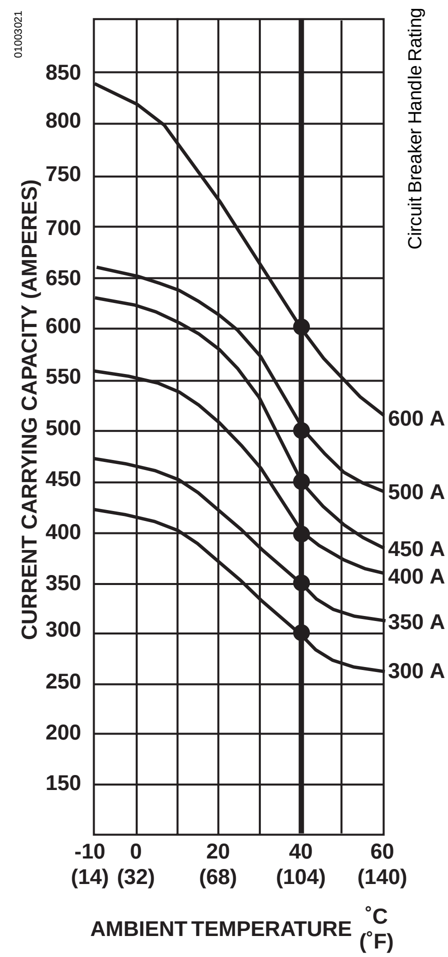

Figure 24: LI Circuit Breakers

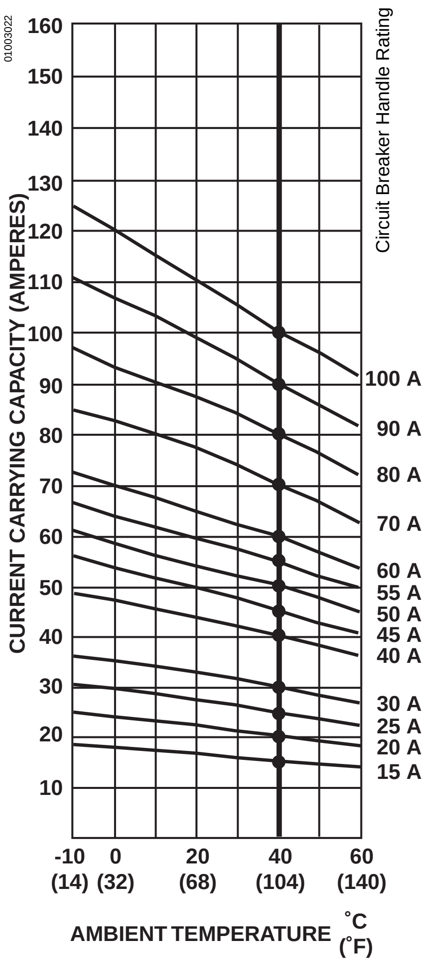

Figure 25: QI-QIT Circuit Breakers

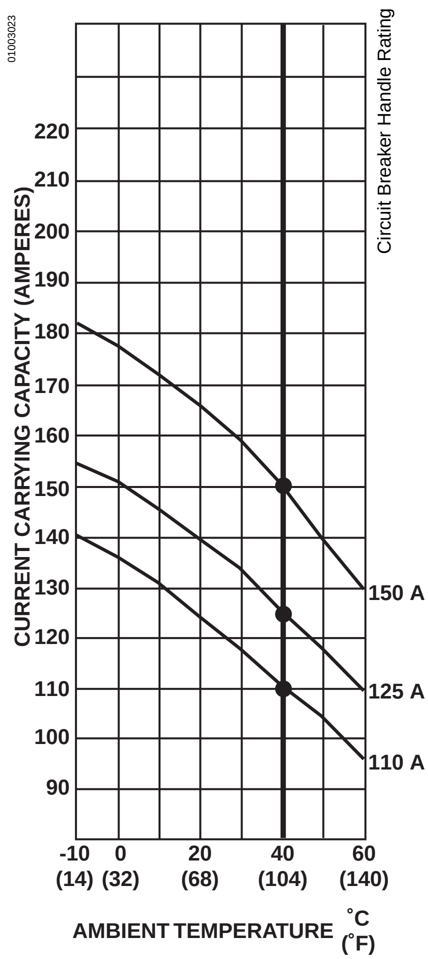

Figure 26: QIA Circuit Breakers

Square D Company
PO Box 3069
3700 Sixth St SW
Cedar Rapids IA 52406-3069 USA
1-888-SquareD (1-888-778-2733)
www.SquareD.com