100%-Rated Circuit Breakers

INTRODUCTION

Knowing when to recommend 100%-rated circuit breakers can mean total project savings, added flexibility for future expansions or modifications, and effective circuit protection.

As explained in Section 210-20(a) of the 1999 National Electrical Code (NEC):

“Where a branch circuit supplies continuous loads or any combination of continuous and non-continuous loads, the rating of the overcurrent device shall not be less than the non-continuous 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 “non-continuous load.”

This exception allows for 100%-rated circuit breakers used in equipment tested and listed for 100% of rating and has led to the phrases “100%-rated circuit breaker” and “standard-rated (80%-rated) circuit breaker.” Underwriters Laboratories Inc. (UL) specifies tests that must be conducted to obtain listings for continuous operation at 100% of rated current.

Additionally, NEC Section 215-2(a) states:

“The minimum feeder-circuit conductor size, before the application of any adjustment or correction factors, shall have an allowable ampacity equal to or greater than the non-continuous load plus 125 percent of the continuous load.

“Exception: Where the assembly, including the overcurrent devices protecting the feeder(s), is listed for operation at 100 percent of its rating, the ampacity of the feeder conductors shall be permitted to be not less than the sum of the continuous load plus the non-continuous load.”

As shown by the following equations for a continuous load:

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125\% \text{ of Continuous Load (standard-rated installation)} = \text{Circuit Breaker Rating.}
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\text{Continuous Load (100%-rated installation)} = \text{Circuit Breaker Rating (Exception)}
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In short, this article says that a standard-rated circuit (circuit breaker and wire) can carry 80% of the circuit breaker and conductor current rating. In contrast, 100% rated circuits can carry 100% of the circuit breaker and conductor current rating.
When applying 100%-rated circuit breakers, there are several UL and NEC restrictions which must be kept in mind. If any of these restrictions are not met, the 100% rated circuit breaker becomes a standard- or 80%-rated circuit breaker.

As specified in paragraph 9.1.4.4 of UL Standard 489:

“A circuit breaker, having a frame size of 250 A or greater, or a multi-pole type of any ampere rating rated over 250 V; and intended for continuous operation at 100 percent of rating, shall be marked: ‘Suitable for continuous operation at 100 percent of rating only if used in a circuit breaker enclosure Type (Cat.No.) ____ or in a cubic space ____ by ____ by ____ mm (inches).’ Equivalent wording shall be permitted. The blanks are to be filled in with the minimum dimensions.”

As specified in paragraph 9.1.2.13 of UL Standard 489:

“When a circuit breaker has been tested using bus bars larger or smaller than those specified in Table 7.1.4.1.3 [shown at left], it shall be marked to show the minimum size bus bar with which it can be used.”

Another restriction applying to 100%-rated circuit breakers is found in an exception to Section 210-20(a) of the NEC quoted above, especially the words:

“Where the assembly, including the overcurrent devices protecting the feeder(s), is listed for operation at 100 percent ...”

This says it is not just the circuit breaker that must be 100% rated; rather, the entire installation must be suitable for 100% operation.

Switchboard manufacturers, including Square D, do not label their enclosures as either 100%-or 80%-rated. Instead, a switchboard is suitable to have 100%-rated circuit breakers installed and applied at 100% if:

1. the minimum enclosure size and ventilation requirements set forth on the circuit breaker are met, or

2. the switchboard has been specifically UL tested for 100% operation of the circuit breaker.

In enclosures that are supplied with standard-rated circuit breakers, it is not necessarily possible to replace a standard-rated circuit breaker with a 100%-rated circuit breaker and obtain a 100% rating. The enclosure must meet the minimum enclosure and ventilation requirements of the circuit breaker and be marked as such.
Load Calculations

When deciding to use standard- or 100%-rated circuits, the solution is not always a clear-cut decision. Taking the following steps will simplify making this decision:

1. Examine loads to determine if they are primarily continuous loads (three or more hours) or non-continuous loads. If all loads are non-continuous, the both standard- and 100%-rated circuit breakers can be sized at 100% of the load and the standard-rated circuit breaker would be the most economical option. However, if some or all of the loads are continuous, a 100%-rated circuit breaker may be the best option.

2. Where possible, segment each distribution circuit into all continuous loads or all intermittent loads. By doing this, the choice of a 100%-rated or a standard-rated circuit breaker will become clear-cut for each circuit.

3. Determine the total load on each branch circuit and calculate the ampere rating required for the circuit breaker and conductor using both a standard-rated circuit breaker and a 100%-rated circuit breaker.

4. Compare the cost of the circuit breaker and conductor for the 100%-rated circuit breaker to that of the standard-rated circuit breaker. The less expensive option is probably the wiser choice, although capability to handle load growth is an additional consideration.

The above steps will help determine whether 100%-rated branch circuit breakers could be efficiently used. To determine whether a 100%-rated main circuit breaker could be efficiently used, follow steps three and four above.
Circuit Example

The following example will help illustrate where the use of 100%-rated circuit breakers can result in a savings for the customer. In this example, there are two branch circuits being fed from the main circuit breaker as shown in the figure below.

**Circuit 1**

1. Using a standard-rated circuit breaker:
   a. Minimum required ampacity = (1000 x 1.25) = 1250 amperes
   b. Because 1250 A is not an available rating, a 1400-ampere circuit breaker would be required.

2. Using a 100%-rated circuit breaker:
   a. Minimum required ampacity = 1000 amperes
   b. A 1000-ampere circuit breaker would be required.

- In this case, the 100%-rated circuit breaker offers two-fold savings: smaller frame size circuit breakers, which may reduce the size of the end-use equipment and the space needed in the electrical room; and smaller conductors.

- Although, if load growth is expected, the standard-rated (1400 A) circuit breaker does have the capacity for 1120 A or 120 amperes load growth.

**Circuit 2**

1. Using a standard-rated circuit breaker:
   a. Minimum required ampacity = (150 x 1.25) + 500 = 687 amperes
   b. Because 687 amperes is not an available rating, 700-ampere conductors and circuit breaker would be required.

2. Using 100%-rated circuit breaker:
   a. Minimum required ampacity = 150 + 500 = 650 amperes
   b. Because 650 amperes is not a standard rating, 700-ampere conductors and circuit breaker would be required.

- In this case, the 100%-rated circuit breaker does not offer savings to the customer. A standard-rated circuit breaker is the most economical choice.

**Main Circuit Breaker**

1. Using a standard-rated circuit breaker:
   a. Minimum required ampacity = (1000 x 1.25) + (150 x 1.25) + 500 = 1937 amperes
   b. The next standard rating for conductors and circuit breakers is 2000 amperes.

2. Using 100%-rated circuit breaker:
   a. Minimum required ampacity = 1000 + 150 + 500 = 1650 amperes
   b. The next available size for circuit breakers and conductors is 1800 amperes.

- Here again, using the 100%-rated circuit breaker will result in a total project cost reduction for the customer. In this case, a savings will be realized in the price of the busway, switchboard bussing, and cable. In addition, the customer has the excess capacity of 150 amperes for future load growth.