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Understanding 100% rated breaker assemblies and their application

■ White Paper

By Rumman Kabir, Senior Application Engineer

Understanding when to implement 100% breaker assembly in an application not only helps comply with National Electric Code(NEC) requirements but also can reduce the overall cost of the project. Circuit breaker manufacturer can pre-certify their breaker for 100% breaker assembly rating with a minimum enclosure dimension. An independent manufacturer can also use a standard breaker that is typically used at 80% rating and recertify it through nationally recognized test laboratories (NRTL) to be used as 100% rated breaker assembly.

Have you ever come across a specification that requires the use of a 100% rated breaker instead of an 80% rated breaker? Or have you ever wondered why there is an 80% rated breaker inside a 100% rated assembly? There are some misunderstandings as to why a 100% breaker assembly is typically used; in this paper we will try to fill some of the knowledge gaps.

It is important to understand what is meant by continuous loads, since this alone drives requirement for an oversized breaker. National Electrical Code (NEC) article 100 defines continuous load as any load that runs 3 hours or more without stopping.

“Continuous Load: A load where the maximum current is expected to continue for 3 hours or more.”

The term “80% rated breaker” does not exist in any Code or Standard that is regularly used. The term is derived from the fact that NEC requires overcurrent protective device to be oversized by 125% for the continuous loads. 80% rating is simply downsizing the breaker to comply with the 125% oversizing requirement since it's simply the inverse. For example, 100A continuous load needs

a 125A minimum sized circuit breaker. Conversely, if you have a 125A breaker, you can only use up to 80% of its rating for continuous loads, or 100A of continuous loads maximum. 100% rated breaker assemblies (note, the rating is for the assembly, not the breaker. Assembly indicates to the enclosure and breaker combination) are allowed to be used up to their full rating. These breaker assemblies can use breakers that are labeled from the manufacturer as 100% rated or standard breakers that are typically used at 80% of their rating. Remember that 100% rating does not apply to breakers; it is only applicable to the whole assembly. The breakers that carry a 100% rating in their label must be installed in a cabinet with the minimum length, width and height specified by the manufacturer in the same label. If an independent manufacturer uses a standard breaker off the market that does not carry a 100% rating in its label, and certify with NRTL with specific assembly dimension, that assembly may carry the same rating as the full current carrying capability of the circuit breaker itself. It does not need to be limited to 80% of its rating for continuous loads.

Breaker Certification Process: Circuit breakers for use in the United States are certified by Nationally Recognized Test Laboratories (NRTL) to their specific standard. Underwriters Laboratory (UL) is the one of the NRTLs for circuit breakers. Their standard labeled UL489 specifies the safety standards for Molded-Case circuit breakers, Molded-Case Switches and Circuit-Breaker Enclosures.

This standard requires that circuit breaker manufacturers test their products for full rated current for an unlimited time. Under standard UL489 test conditions, the circuit breakers are tested in free air and in ambient temperatures of 40° Celsius. The standard recognizes that these are not normal operating conditions, and most likely these circuit breakers will be housed in an enclosure that does not allow the same amount of airflow as the test circuit. These applications will result in higher temp rises within the enclosure during normal operating conditions, especially for continuous loads. If this temperature rise exceeds the operating conditions of the thermo magnetic breakers, it may cause nuisance tripping of the breakers. For continuous loads, standards only allow circuit breakers to be used at 80% of their rating. Hence NEC also recommends that for standard enclosure applications the circuit breakers are oversized 125% (same as 80% derate) for continuous loads. Thereby the standard circuit breakers are listed to have an 80% continuous rating.

To be rated 100% rated, an enclosure must be designed specifically with a breaker. This enclosure must allow sufficient airflow around the breaker for cooling the mechanism. The circuit breaker assembly must go through additional testing to be recognized and listed.

A NRTL performs tests with full rated current for an unlimited period of time. NRTLs test to make sure that under continuous operation the temperature rise inside the enclosure does not exceed the operational limits of the breakers and it does not trip prematurely. A standard breaker can be used for the 100% assembly rating test. After passing the test, NRTL certifies the breaker and the assembly to be 100% rated and per article 9.1.4.4 of UL489 standard, requires the manufacturer to use a label with the following verbiage which lists the minimum enclosure requirement.

“9.1.4.4 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 cubicle space ____ by ____ by ____ mm (inches)”. Equivalent wording shall be permitted. Location Category C. The blanks are to be filled in with the minimum dimensions.”

Remember that without a NRTL label using equivalent verbiage, the 100% rating will not be allowed on the circuit breaker assembly. NRTL issues a file number to the certification which is also added to the label of the 100% rated breaker assembly. Notice that the NRTL specifically lists the specific cubicle space and circuit breaker type so that only this combination can be used to retain the 100% breaker assembly rating. Authorities Having Jurisdiction (AHJ) or local inspectors can verify UL recognition by looking up the file number in online certification directory.

<http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/index.html>

A circuit breaker manufacturer can predefine the minimum enclosure size required for a breaker tested to 100% rating. In that case the user must make sure that the enclosure has the specified minimum dimensions listed in the label. Alternatively, an independent manufacturer can test the assembly (Circuit breaker and Enclosure) with NRTL and install the label on the enclosure.

For example, Cummins Power Generation certifies its own 100% rated breaker assembly by taking circuit breakers by industry standard manufacturers and recertifying them with NRTL using specially designed enclosures. These breaker assemblies are rated for continuous rating up to 600 VAC per UL and suitable to be used as service equipment. The following label is applied inside the circuit breaker assembly

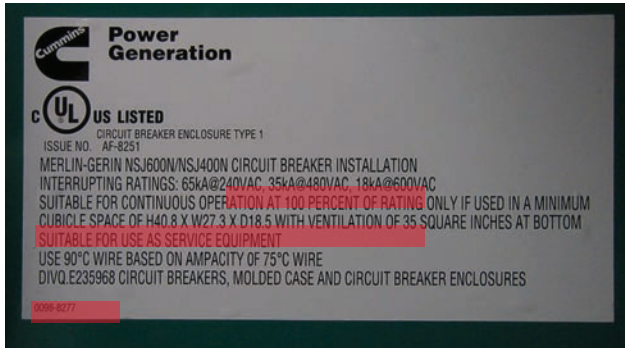


Figure 1.1: UL label of a Cummins 100% rated breaker assembly. This label is typically located inside the enclosure.

Notice that in Figure 1.1 the circuit breaker model is called out without specific requirements for it to be a 100% rated breaker. The breaker for this assembly can be a breaker with model number that starts with NSJ600N or NSJ400N as marked on the label. UL certifies that this assembly is suitable for 100% rating with the minimum cubicle space and ventilation space. UL also requires the cables to be 90° C wires per NEC but based on 75° C ampacity cables. This is a requirement on all 100% rated circuit breaker assemblies. This means one must calculate the 75° C wires for the required ampacity and then use 90° C rated cables for the same circular mils. For example, if a 400A 100% rated breaker is used, table 310.15(B)(16) section for copper cable in NEC suggests the use of one 600 MCM copper cable at 75°C temperature rating. According to the label in figure 1.1, one would have to use a 600 MCM copper cable at 90°C to be used with the 400A 100% rated circuit breaker assembly. This is required due to the higher temperature rise the circuit breaker will encounter due to the continuous loads. Oversized cable allows the heat in the circuit breaker and lugs to be transferred more efficiently and thereby reducing the chance of overheating. For breakers, over heating is undesirable since that may cause breaker to trip unexpectedly.

NRTLs also require follow up testing to ensure quality of the 100% rated assemblies. In Figure 1.1, the last line calls out the file number DIVQ.E235968. This file number is only applicable to this 100% breaker assembly by Cummins Power Generation and can be verified online. In the NRTLs certification website, input company name 'Cummins' and category code 'DIVQ'. The resulting certification is shown below in Figure 1.2. Inspectors can verify protection in this method.

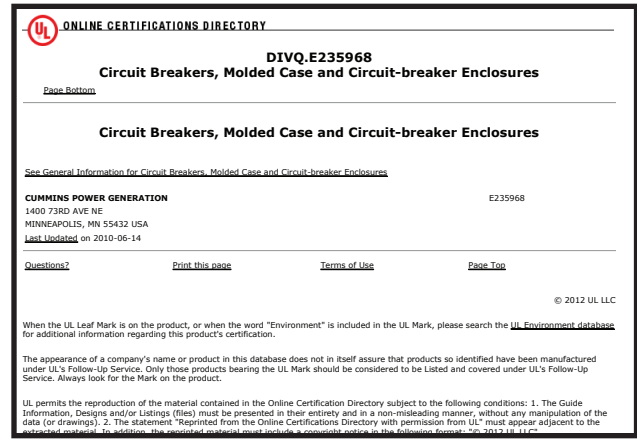


Figure 1.2: UL online certification of Cummins 100% rated breaker assembly.

Code Requirements: Certain sections in National Electric Code (NEC) drive the requirement of oversizing a circuit breaker for load protection. NEC 2011 article 210.20 (a) requires the size of the Overcurrent protection device (most commonly breaker) to be oversized by 125% for the continuous portion of the loads. Here the exception allows the use of the 100% rated breakers where the assembly is listed for operation at 100% of its rating:

“210.20 Overcurrent Protection: Branch-circuit conductors and equipment shall be protected by overcurrent protective devices that have a rating or setting that complies with 210.20(A) through (D).

(A)Continuous and Noncontinuous Loads: 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.”*

The key words for the allowed exception are **Assembly** and **Listed**. **Assembly** indicates to the complete circuit breaker assembly including the circuit breaker and the cabinet. Also note that NEC is requiring the Assembly to be **listed** by a nationally recognized test laboratory (NRTL). It does not require the circuit breaker to have 100% rating, but the whole assembly should be tested to the standard.





About the author

Rumman Kabir is a Senior Application Engineer for Cummins Power Generation. In this role he supports distributors, field service engineers for proper implementation of Cummins Power Generation products and also presents in technical seminars. He specializes in Generator set Controls,

Paralleling Systems, Transfer Switches and Generator electrical components. Rumman is a graduate of the Minnesota State University with Bachelor of Electrical Engineering. He joined Cummins in 2008 starting as a Controls Engineer. He has also served as the Control Application and Support Lead for the Asia Pac region from CPG Singapore.

It is important to note that the 125% oversizing of the overcurrent protective device applies only for the total continuous load. Meaning if there are 600A of continuous load and 200A of noncontinuous load, the total size of the overcurrent device should be 125% of 600A continuous load plus 200A non continuous. This results in total load of $(1.25 \times 600 + 200)$ 950A. So in this case the overcurrent protection device should be at least 950A rating. Now if a 100% rated breaker is used, the minimum size of the breaker should be the sum of the continuous and non continuous load. This totals to be $(600+200)$ 800A. In this case, an 800A 100% rated breaker can be used.

NEC article 215.2 (A)(1) also imposes similar oversizing requirement for conductors.

“215.2 Minimum Rating and Size.

(A) Feeders Not More Than 600 Volts.

(1) **General.** Feeder conductors shall have an ampacity not less than required to supply the load as calculated in Parts III, IV, and V of Article 220. The minimum feeder-circuit conductor size, before the application of any adjustment or correction factors, shall have an allowable ampacity not less than the noncontinuous load plus 125 percent of the continuous load.

Exception No. 1: *If the assembly, including the overcurrent devices protecting the feeder(s), is listed for operation at 100 percent of its rating, the allowable ampacity of the feeder conductors shall be permitted to be not less than the sum of the continuous load plus the noncontinuous load.*

Exception No. 2: *Grounded conductors that are not connected to an overcurrent device shall be permitted to be sized at 100 percent of the continuous and noncontinuous load.”*

In this section NEC requires that, the feeder's ampacity should be the sum of noncontinuous loads plus 125%

of the continuous loads. If overcurrent device assembly protecting the feeder is listed for operation at 100% rating, and then the ampacity shall at minimum be the sum of noncontinuous and continuous loads. Under this exception, one can select a breaker assembly with 100% rating and use up to its full rating.

It becomes quickly apparent that use of a 100% rated breaker assembly can allow the use of a smaller frame breaker and also smaller size conductor. This can reduce cost of the overall project greatly and also leave room for future expansion. If the cable to the loads are at a far enough distance, the cost reduction by using lower ampacity cables may justify the higher costing 100% rated breaker assembly.

Conclusion:

In summary, a 100% rating can help in reducing the overall cost of the project by reducing both breaker and cable size. 100% rating is only applicable to a circuit breaker as an assembly. The 100% rated assembly can carry a standard breaker that does not include a 100% rating label from its manufacturer. An independent manufacturer can acquire 100% circuit breaker assembly rating by performing additional testing with a NRTL. Rating verification can be done directly through the certification directory online.



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