240.86 Series Ratings.

Where a circuit breaker is used on a circuit having an available fault current higher than its marked interrupting rating by being connected on the load side of an acceptable overcurrent protective device having the higher rating, 240.86(A) and (B) shall apply.

(A) Marking. The additional series combination interrupting rating shall be marked on the end use equipment, such as switchboards and panelboards.

(B) Motor Contribution. Series ratings shall not be used where

(1) Motors are connected on the load side of the higher-rated overcurrent device and on the line side of the lower-rated overcurrent device, and

(2) The sum of the motor full-load currents exceeds 1 percent of the interrupting rating of the lower-rated circuit breaker.

A series rated system is a combination of circuit breakers, or fuses and circuit breakers, that can be applied at available short-circuit levels above the interrupting rating of the load side circuit breakers, but not above that of the main or line-side device. Series rated systems can consist of fuses that protect circuit breakers or of circuit breakers that protect circuit breakers.

Section 240.86(A) requires that, when a series rating is used, the switchboards, panelboards, and load centers be marked for use with the series rated combinations that may be used. Therefore, the enclosures must have a label affixed by the equipment manufacturer that provides the series rating of the combination(s). Because there is often not enough room in the equipment to show all the legitimate series rated combinations, UL 67 (Panelboards) allows for a bulletin to be referenced and supplied with the panelboard. These bulletins typically provide all the acceptable combinations. Note that the installer also has an additional labeling requirement (see 110.22).

One critical requirement limits the use of series rated systems in which motors are connected between the line-side (protecting) device and the load-side (protected) circuit breaker. Section 240.86(B) requires that series ratings not be used where the sum of motor full-load currents exceeds 1 percent of the interrupting rating of the load-side (protected) circuit breaker, as illustrated in Exhibit 240.14.

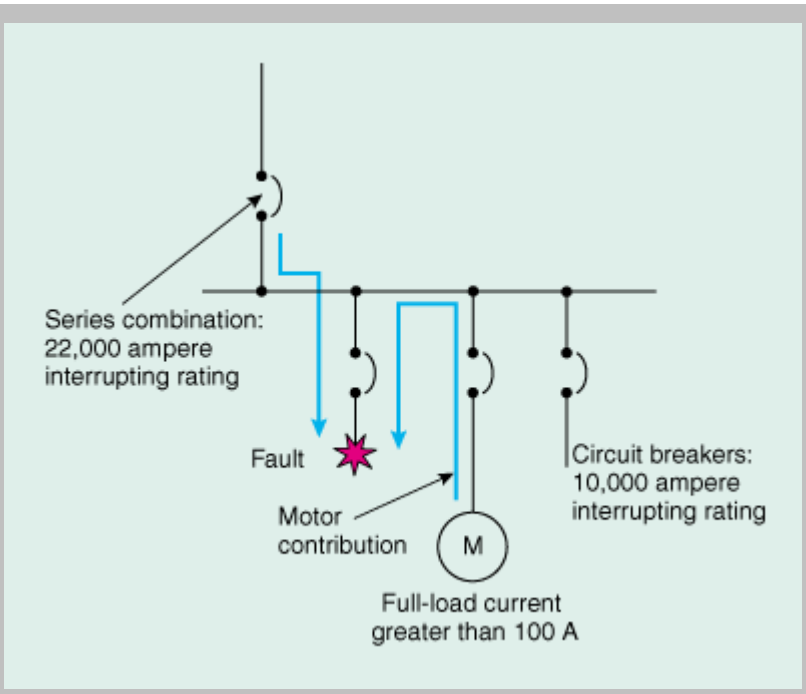


Exhibit 240.14 Example of violation of 240.86(B) due to motor contributions.

110.9 Interrupting Rating

Equipment intended to interrupt current at fault levels shall have an interrupting rating sufficient for the nominal circuit voltage and the current that is available at the line terminals of the equipment.

Equipment intended to interrupt current at other than fault levels shall have an interrupting rating at nominal circuit voltage sufficient for the current that must be interrupted.

The interrupting rating of overcurrent protective devices is determined under standard test conditions. It is important that the test conditions match the actual installation needs. Section 110.9 states that all fuses and circuit breakers intended to interrupt the circuit at fault levels must have an adequate interrupting rating wherever they are used in the electrical system. Fuses or circuit breakers that do not have adequate interrupting ratings could rupture while attempting to clear a short circuit.

Interrupting ratings should not be confused with short-circuit current ratings. Short-circuit current ratings are further explained in the commentary following 110.10.

110.10 Circuit Impedance and Other Characteristics

The overcurrent protective devices, the total impedance, the component short-circuit current ratings, and other characteristics of the circuit to be protected shall be selected and coordinated to permit the circuit-protective devices used to clear a fault to do so without extensive damage to the electrical components of the circuit. This fault shall be assumed to be either between two or more of the circuit conductors or between any circuit conductor and the grounding conductor or enclosing metal raceway. Listed products applied in accordance with their listing shall be considered to meet the requirements of this section.

In the 1999 *Code*, the word *current* was substituted for the obsolete word *withstand*. That change correlated the *Code* language with the standard marking language used on equipment. Withstand ratings are not marked on equipment, but short-circuit current ratings are. This marking appears on many pieces of equipment, such as panelboards, switchboards, busways, contactors, and starters. Additionally, the last sentence of 110.10 is meant to address concerns of what exactly constitutes ``extensive damage." Because, under product safety requirements, electrical equipment is evaluated for indications of extensive damage, listed products used within their ratings are considered to have met the requirements of 110.10.

The basic purpose of overcurrent protection is to open the circuit before conductors or conductor insulation is damaged when an overcurrent condition occurs. An overcurrent condition can be the result of an overload, a ground fault, or a short circuit and must be eliminated before the conductor insulation damage point is reached.

Overcurrent protective devices (such as fuses and circuit breakers) should be selected to ensure that the short-circuit current rating of the system components is not exceeded should a short circuit or high-level ground fault occur.

System components include wire, bus structures, switching, protection and disconnect devices,

and distribution equipment, all of which have limited short-circuit ratings and would be damaged or destroyed if those short-circuit ratings were exceeded. Merely providing overcurrent protective devices with sufficient interrupting rating would not ensure adequate short-circuit protection for the system components. When the available short-circuit current exceeds the short-circuit current rating of an electrical component, the overcurrent protective device must limit the let-through energy to within the rating of that electrical component.

Utility companies usually determine and provide information on available short-circuit current levels at the service equipment. Literature on how to calculate short-circuit currents at each point in any distribution generally can be obtained by contacting the manufacturers of overcurrent protective devices or by referring to IEEE 141-1993, *IEEE Recommended Practice for Electric Power Distribution for Industrial Plants* (Red Book).

For a typical one-family dwelling with a 100-ampere service using 2 AWG aluminum supplied by a 371/2 kVA transformer with 1.72 percent impedance located at a distance of 25 ft, the available short-circuit current would be approximately 6000 amperes.

Available short-circuit current to multifamily structures, where pad-mounted transformers are located close to the multimetering location, can be relatively high. For example, the line-to-line fault current values close to a low-impedance transformer could exceed 22,000 amperes. At the secondary of a single-phase, center-tapped transformer, the line-to-neutral fault current is approximately one and one-half times that of the line-to-line fault current. The short-circuit current rating of utilization equipment located and connected near the service equipment should be known. For example, HVAC equipment is tested at 3500 amperes through a 40-ampere load rating and at 5000 amperes for loads rated more than 40 amperes.

Adequate short-circuit protection can be provided by fuses, molded-case circuit breakers, and low-voltage power circuit breakers, depending on specific circuit and installation requirements.

Component Protection — Circuit Breaker Protection

Generally, a circuit breaker should not be applied where the available short-circuit current at its line side terminals exceeds the circuit breaker's interrupting rating. This is a requirement per 110.9. However, 240.86 has an allowance for fuses or circuit breakers to protect downstream circuit breakers where the available short-circuit current exceeds the downstream circuit breaker's interrupting rating. The term given to this is a series rated combination, series rating, or series combination rating. The application of series ratings has many technical limitations and additional NEC® requirements that must be met for proper application. Series rated combinations allowed per 240.86 should be used sparingly. The most suitable and often the only proper application of series rated combinations is for branch circuit, lighting panels. At the end of this section are tables of commercially available fuse/circuit breaker series rated combinations published by panelboard and switchboard manufacturers. These tables, along with a compliance check list for evaluating a series rated combination for a specific installation can be viewed or downloaded from www.bussmann.com.

First, it is best to understand the definitions of fully rated and series rated. As far as interrupting ratings are concerned, fully rated systems are recommended and can be used everywhere, as long as individual interrupting ratings are in compliance with 110.9. On the other hand, series rated combinations have limited applications and have extra NEC® requirements that must be met.

Fully Rated

A fully rated system is one in which all of the overcurrent protective devices have an individual interrupting rating equal to or greater than the available short-circuit current at their line terminals per 110.9. Fully rated systems can consist of all fuses, all circuit breakers, or a combination of fuses and circuit breakers. The interrupting rating of a branch circuit fuse is required by 240.60 to be marked on the fuse (unless its interrupting rating is 10,000 A). The interrupting rating of a branch circuit circuit breaker is required by 240.83 to be marked on the circuit breaker (unless its interrupting rating is 5,000 A). In this section, "individual" or "stand-alone" interrupting rating is used to denote the interrupting rating of a circuit breaker or fuse. It is the "individual" or "stand-alone" interrupting rating that is marked on a fuse or circuit breaker. See Figure 1. A major advantage with modern current-limiting fuses is that they have interrupting ratings of 200,000 or 300,000 amperes.

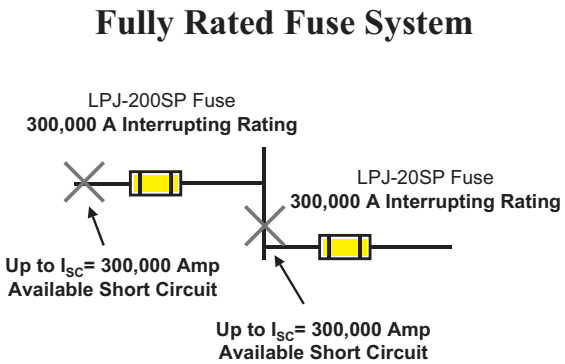


Figure 1

Series Rated Combinations

A series rated combination is a specific combination of circuit breakers or fuses and circuit breakers, that can be applied at available short-circuit current levels above the interrupting rating of the load side (protected) circuit breaker, but not above the interrupting rating of the line-side (protecting) device. A series rated

combination can consist of fuses protecting circuit breakers, or circuit breakers protecting circuit breakers. Figure 2 illustrates a fuse/circuit breaker series rated combination. Testing to UL 489 determines the series combination interrupting rating, but this interrupting rating is not marked on circuit breakers or fuses. As will be shown in this section, the manufacturer of the panelboard, loadcenter, switchboard or other equipment in which the protected circuit breaker is installed must mark the equipment with the details of a tested series rated combination.

CAUTION: *A series rated combination allows a load side (protected) circuit breaker to be applied where the available short circuit current exceeds the interrupting rating marked on that circuit breaker.*

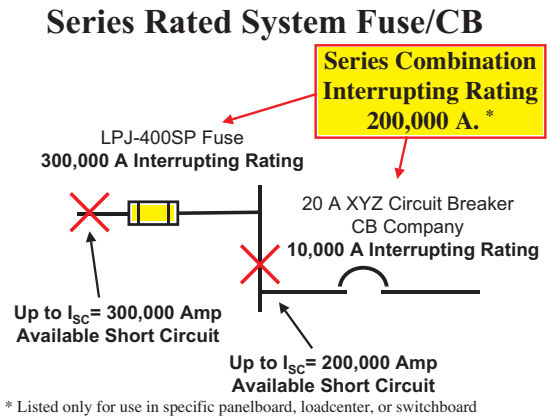


Figure 2

How Is A Series Rated Combination Listed?

The industry has devised a method for a National Recognized Testing Laboratory (NRTL) to test a combination of a manufacturer's specific type and size circuit breaker beyond its marked interrupting rating when protected by specific type line side fuses of a maximum ampere rating. A National Recognized Testing Laboratory (NRTL) does not list the fuse/circuit breaker combination by itself as a series rated combination. The listing for a series combination has to be evaluated and found suitable for a specific manufacturer's panelboard, loadcenter, switchboard or other equipment.

Section 240.86(A) requires that, when a series rating is used, the switchboard, panelboard, loadcenter, or other equipment be marked by the manufacturer for use with the series rated combinations to be utilized. This indicates that the appropriate switchboard, panelboard or loadcenter assembly has been investigated for such use with the specific series rated combination. For instance, the series rated combination shown in Figure 2 is tested and marked for use in a particular manufacturer's panelboard type as shown in Figure 3. Notice in these two figures that the load side circuit breaker has an individual marked interrupting rating of only 10,000A. But with the series rated combination testing and marking, it may be possible to use it where 200,000A of available short-circuit current are available. Also, note that this rating applies to (1) a specific manufacturer's type and size circuit breaker, (2) when used in a specific manufacturer's type panelboard, switchboard line, or other equipment, (3) when protected on the line side by a specific maximum ampere rating and class fuse and (4) the panelboard is factory marked with the necessary series combination rating specifics. The line side (protecting) fuse can be installed in the same panelboard or a separate enclosure.

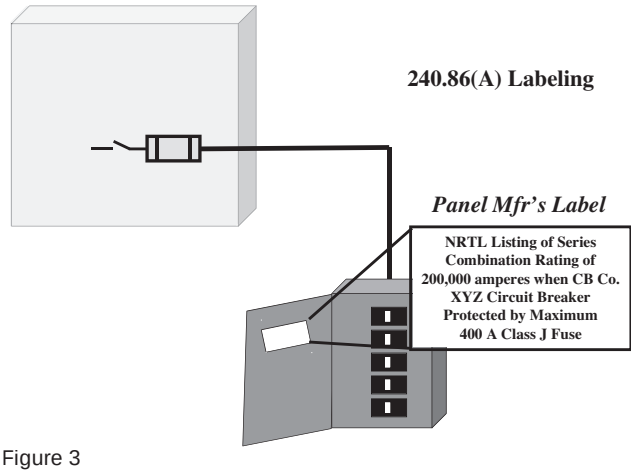


Figure 3

Because there is often not enough room in the equipment to show all of the legitimate series rated combinations, UL 67 (Panelboards) allows for a bulletin to be referenced and supplied with the panelboard. These bulletins typically provide all of the acceptable series rated combinations for that panelboard.

Unfortunately, using manufacturers' literature, it is often difficult to determine which combinations go with which panelboards. In order to clear the confusion, Bussmann® has researched the major manufacturers' application literature and published the tables at the end of this section. These tables show, by manufacturer, the various series rated combinations of fuses and breakers that are acceptable by panelboard and switchboard type. Note more combinations may be available for loadcenters and metercenters; refer to the equipment manufacturer's literature.

Although series rated combinations save a small percentage of the initial equipment costs, there are many issues about designing and utilizing series rated combinations. If series rated combinations are considered for use, there are other NEC® requirements that must be met! Since series rated combinations are evaluated by laboratory testing under specific conditions, these other requirements are extremely important to make sure a series rated combination is, in fact, applied per its testing, listing and marking [110.3(B)].

Requirements In Applying Series Rated Combinations

240.86(A) Factory Labeling Requirement

As just discussed, 240.86(A) requires that, when a series rated combination is used, the switchboard, panelboard or other equipment be tested, listed and **factory marked** for use with the series rated combinations to be utilized. See Figure 4 for the 110.22 & 240.86(A) labeling requirements illustration.

110.22 Field Labeling Requirement

This section places responsibility on the **installer** (electrical contractor) to **affix labels** on the equipment enclosures, which note the series combination interrupting rating, and calls out the specific replacement overcurrent protective devices to be utilized. If the upstream overcurrent protective device protecting the downstream circuit breaker is in a different enclosure, then *both* enclosures need to have field-installed labels affixed. See Figure 4 for the 110.22 & 240.86(A) labeling requirements illustration.

240.86(A) Factory Labeling Requirement
110.22 Field Labeling Requirement

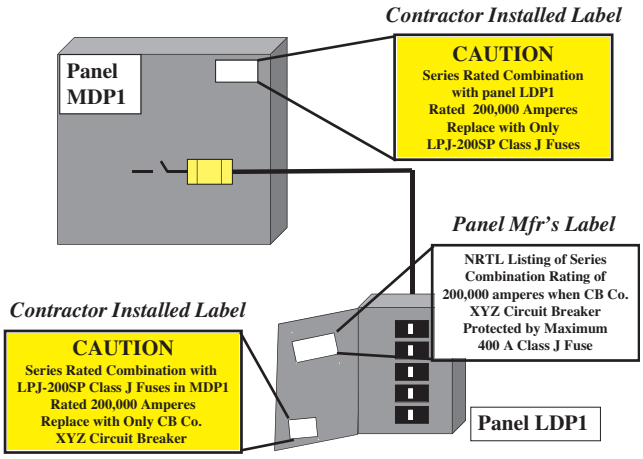


Figure 4

240.86(B) Motor Contribution Limitations

This is a major limitation. It is critical for initial installations but in addition, future system changes can negate the series combination rating. Where motors are connected between the line side (protecting) device and the load side (protected) circuit breaker, 240.86(B) has a critical limitation on the use of series rated combinations. This section requires that a series rated combination shall not be used where the sum of **motor full load currents exceeds 1% of the load side (protected) circuit breaker's individual interrupting rating**. See Figure 5. The reason is that when a fault occurs, running motors momentarily contribute current to the short-circuit (usually about four to six times their full load rating). This added motor contribution results in a short-circuit current in excess of what the loadside (protected) circuit breaker was tested to handle in relation to the lineside (protecting) device per the series rated combination testing. See Figure 6.

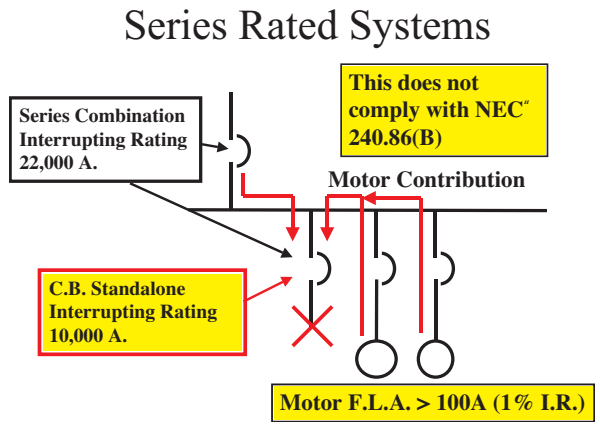


Figure 5

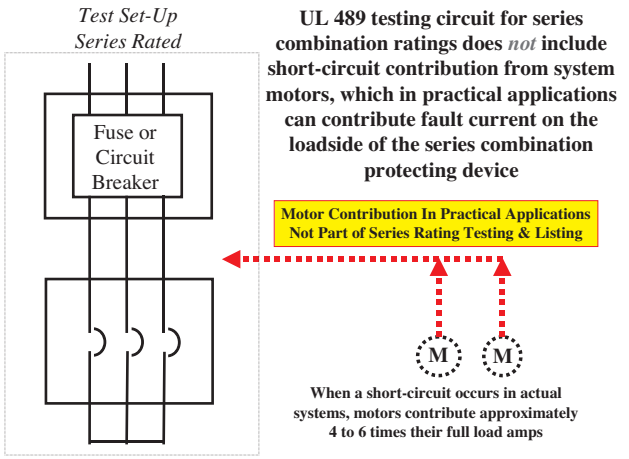


Figure 6

This is one of the major reasons that series rated combinations are generally recommended only for lighting panel applications. Lighting panels typically do not have significant motor loads so the motor contribution between the feeder overcurrent device and lighting panel branch-circuit circuit breakers is not an issue upon initial installation or in the future. However, series rated combinations used for power panel or main/feeder applications can often pose a problem upon initial installation or if the loads change in the future.

Example 1

As an example of the implications of 240.86(B) look at Figure 7. On an installation with a 1000 amp total load, 50% motor load (which is motor load of 500 amperes), the motor contribution could be an issue in selecting a series rated combination. If a main/feeder series rating were to be considered, the feeder circuit breaker must have at least a 50,000 ampere individual or standalone interrupting rating per 240.86(B) (1% of 50,000 = 500). If the protected circuit breaker has to have an individual interrupting rating of at least 50,000 A, it negates the reason that series rated combinations are utilized for most applications.

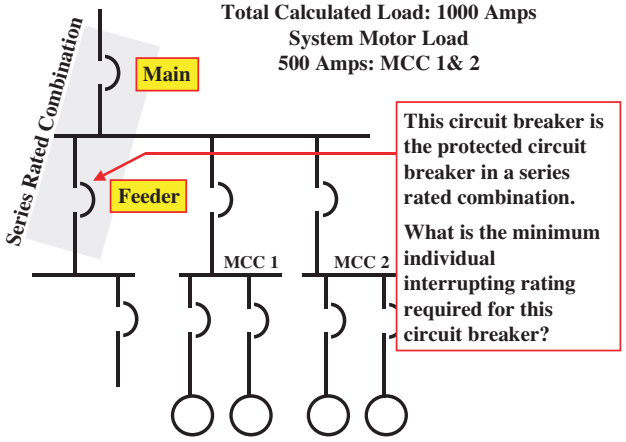


Figure 7

Example 2

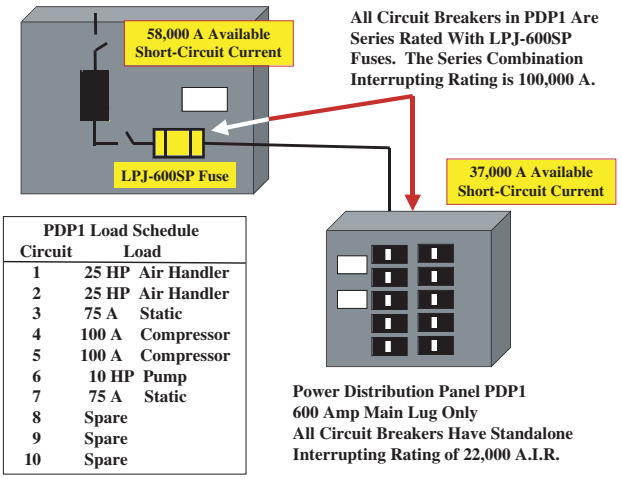
Below is an easy to use table to evaluate the "protected" (loadside) circuit breaker in a series rated combination for meeting the motor contribution limits in 240.86(B). In the Figure 7 example, the motors that are connected that could contribute current where the feeder circuit breaker ("protected" device of the series combination) would have to interrupt but that the main circuit breaker ("protecting" device of the series combination) would not have to interrupt is represented by 500 amperes of normal full load current. Reading the table below, it is seen that 500 amperes full load motor current exceeds 420A in column A. Therefore, a series rating with a "protected" circuit breaker having a standalone interrupting rating of 42,000 A.I.R. is insufficient to meet 240.86(B). A series combination that uses a "protected" circuit breaker with a standalone interrupting rating of at least 50,000A would be required to meet 240.86(B). Note; do not confuse the standalone interrupting rating of the "protected" circuit breaker with the series combination interrupting rating. The series combination interrupting rating is the rating for both devices working together to interrupt short-circuit currents. The series combination interrupting rating is much greater than the standalone interrupting rating of the "protected" circuit breaker.

Motor Full Load Amps Shall Not Exceed This Value, If Using Series Combination With "Protected" Circuit Breaker Having Standalone Interrupting Rating In Column B (A)	"Protected" Circuit Breaker Standalone Interrupting Rating In Series Combination (B) *	Motor Full Load Amps Shall Not Exceed This Value, If Using Series Combination With "Protected" Circuit Breaker Having Standalone Interrupting Rating In Column B (A)	"Protected" Circuit Breaker Standalone Interrupting Rating In Series Combination (B) *
75A	7500 AIR	250A	25,000 AIR
100A	10,000 AIR	300A	30,000 AIR
140A	14,000 AIR	350A	35,000 AIR
180A	18,000 AIR	420A	42,000 AIR
200A	20,000 AIR	500A	50,000 AIR
220A	22,000 AIR	650A	65,000 AIR

* Some possible circuit breaker interrupting ratings per UL 489, Table 8.1

Example 3

Assess the series combination rating for motor contribution limits in the following system.



Step 1: Motor Load

(2) 100A Compressors	200A
(2) 25 HP Motors @ 34A ea.	68A
(1) 10 HP Pump @ 14A	14A
Total Motor Load Connected Between Series Rated Devices	282A

Step 2: Is the Series Rated Combination Shown Acceptable?

No. The series combination shown has a series combination interrupting rating of 100,000A, which is sufficient for the 37,000 amperes available short-circuit current at PDP1. And the LPJ-600SP fuses have an interrupting rating of 300,000 amperes, which is sufficient for the 58,000 amperes available short-circuit current at the main switchboard. However, the "protected" circuit breakers of the series combination, which are located in PDP1, have a standalone or individual rating of 22,000 amperes. The motor load connected between the protecting and protected devices in the series rated combination can not exceed 1% of the protected circuit breaker's standalone interrupting rating. The motor load is 282 amperes, which exceeds 1% of 22,000 amperes (220A). So this series rated combination applied as shown does not comply with 240.86(B).

Then consider the uncertain future of building spaces. For instance, many building spaces, such as office buildings, manufacturing facilities, institutional buildings, and commercial spaces, by their nature, incur future changes. A properly designed and initially installed series combination rating could be compromised if the building loads change to a larger percentage of motor loads.

As just illustrated, it is not enough to only check the available short-circuit current against the series combination interrupting rating. 240.86(B) also requires that the designer, contractor, and AHJ investigate the individual or standalone interrupting rating of the protected circuit breaker of a series combination. This is necessary for series rated combinations for new installations as well as existing series rated combinations when existing systems are refurbished or upgraded.

Selective Coordination Requirement Limitations

Inherently, series rated combinations cannot be selectively coordinated. In order to protect the loadside circuit breaker, the lineside (protecting) device must open in conjunction with the loadside (protected) circuit breaker. This means that the entire panel can lose power because the device feeding the panel must open even under relatively low-level short-circuit conditions.

Therefore, in health care facilities where selective coordination for ground faults is required per 517.17 between the main and feeders, the application of series rated combinations does not meet this requirement. Also, the application of series rated combinations violate the selective coordination requirements for elevator circuits per 620.62. The application of series rated combinations reduces emergency circuit overall system reliability as presented in 700.25 FPN because of their inherent lack of fault current coordination. See Figure 8.

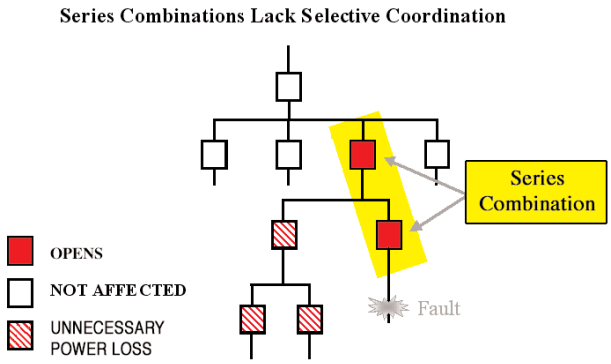


Figure 8

Component Protection

Using series rated combinations does not assure protection for the circuit components. The series rating only pertains to the overcurrent protective devices. Specifically, it means that the load side circuit breaker of lower interrupting rating can be used in an application with higher available short circuit currents. In practical applications, the other circuit components, such as conductors, busway, contactors, etc., should independently be assessed for protection under the worst-case short circuit conditions.

Which Is Best: Fully Rated or Series Rated?

Fully rated systems are the preferred choice for many reasons. If fully rated fuses are used and the proper choices are made, the systems will not have any of the limitations described in the previous paragraphs. In addition, if a fully rated system uses modern current-limiting fuses with interrupting ratings of 200,000A and higher, the system will likely remain fully rated over the life of the system even if changes or additions occur that increase the available short-circuit current.

Series rated combinations should be used sparingly. The most suitable application for series rated combinations is for branch circuit, lighting panel circuit breaker protection. In today's market place, lighting panelboards are only commercially available utilizing circuit breakers for the branch circuits. Also, lighting panels typically do not have significant motor loads so the motor contribution limitation [240.86(B)] is not an issue for series rated combinations in lighting panelboard applications. However, series rated combinations used for power panel or main/feeder applications can pose a problem upon initial installation or if the loads change in the future.

A recommendation is to use lighting panels with circuit breakers that are series rated with feeder fuses. Then for the remainder of the system, use fully rated fuses for all power panelboards, distribution panelboards, motor control centers, motor branch circuits, emergency circuits, elevator circuits and switchboards.

Series rated combinations inherently can not be selectively coordinated. This is a major limitation that most building owners or tenets do not want to incur. To unneccessarily blackout a portion of an electrical system in todays business evnironment, technology driven health care systems, or emergency circuits is unacceptable. Consider the consequences if there is a disaster to a portion of the building; it is important for safety egress to have as much of the electrical system in service as possible.

If Using Series Ratings, What Line Side Choice Considerations Are There?

Remember that with a series rated combination, the load side circuit breaker is applied beyond its individual interrupting rating. Because of this, if a series rated combination is to be used, the designer and contractor should select the tested and marked line side protection that will assure reliable performance over the lifetime of the electrical system. If the line side (protecting) overcurrent protective device does not react as intended, due to lack of maintenance or loss of calibration, the load side circuit breaker may be on its own to interrupt the short-circuit current.

For the reasons mentioned in the previous paragraph, if series rated combinations are going to be used, it is recommended to use fuses as the line side (protecting) devices. Modern current-limiting fuses are the most reliable overcurrent protective devices available. Periodic maintenance of fuses is not required. It is recommended that disconnects and all conductor and fuse terminations be periodically assessed and maintained. However, whether it is the first day of service or thirty years later, modern current-limiting fuses will respond to protect the circuit components as originally designed.

If and when fuses are called upon to open on an overcurrent, installing the same type and ampere rated fuses provide the circuit with new factory-calibrated fuses. The original design integrity can be maintained throughout the life of the electrical system. With fuses there is typically no worry about putting an incorrect one in per the series rating. Modern current-limiting fuses have mountings that only accept the same class fuse. All the testing, listing and marking of series rated combinations that utilize fuses as the line side (protecting) device are tested with the maximum ampere rated fuse that fits into the fuse clip. For instance, all the series ratings with line side fuses are at the maximum ampere ratings for standard fuse clips of 100A, 200A, 400A, and etc.

In contrast, if circuit breakers are used as the line side (protecting) devices in a circuit breaker/circuit breaker series rated combination, periodic maintenance and periodic testing are required per the circuit breaker manufacturers' recommendations, NFPA 70B, and NEMA. If and when the line side (protecting) circuit breaker is called upon to interrupt a fault current to protect the load side (protected) circuit breaker, it is absolutely necessary that this line side circuit breaker operate with the same or better speed and let-through characteristics as if it were newly manufactured. Therefore, owners must periodically examine and electrically test their circuit breakers to the manufacturer's stated maintenance and testing recommendations. If and when the line side circuit breaker is called upon to interrupt a fault, per the manufacturers' recommendations, the circuit breaker should be examined for damage and electrically tested for calibration and operation. Molded case circuit breakers and insulated case circuit breakers cannot be repaired if they are damaged, inoperative, or out of calibration, they must be replaced. If a circuit breaker that is part of a series combination rating is replaced, it is absolutely imperative to install the exact same type and size circuit breaker as the originally installed series rated combination. Circuit breakers of different voltage ratings, different interrupting ratings and potentially different let-through characteristics are physically interchangeable; therefore, the installer must be sure to install the proper replacement circuit breaker.

Caution: *Even with diligent field maintenance of a circuit breaker, mid to high level short circuit currents can drastically reduce the life and change the performance of a circuit breaker, specifically the line side (protective) circuit breaker, and possibly require replacement. There is no field maintenance or testing procedures that can verify a circuit breaker meets the original manufactured specification for speed of operation or let-through characteristics under medium to high-level short circuit currents at rated voltage. Consult the appropriate device manufacturer for verification of the proper performance of the series rated combination following a fault condition; replacement of one or both devices may be required.*

What about the consistency of short-circuit current performance for the commercially available line side (protecting) devices?

The line side fuses used for testing for series rated combinations are special "umbrella" fuses that intentionally exceed the maximum short circuit current let-through values for specific fuse classes and ampere ratings per UL/CSA/ANCE 248 Fuse Standards. This adds an extra safety factor; these special "umbrella" fuses insure that the short-circuit current let-through energy represents the worst case for all the commercially available fuses of that ampere rating and class. (Umbrella fuses are not commercially available. They are sold only to electrical equipment manufacturers for testing purposes.) And as mentioned previously, it is an umbrella fuse of the largest ampere rating that fits in a given ampere rated fuse clip. In addition, the commercially available fuses undergo periodic follow up testing witnessed by the NRTL listing agency to verify that the products continue to have short circuit let-through values under the umbrella limits. Circuit breaker industry standards for the majority of the circuit breakers used (non current-limiting circuit breakers), do not have established short-circuit current let-through limits (umbrella let-through values) as do the fuse industry standards for current-limiting fuses. Consequently, during the testing to establish circuit breaker/circuit breaker series combination ratings, commercially available line side (protecting) circuit breakers are utilized rather than "umbrella" circuit breakers. Granted there is a difference with circuit breaker/circuit breaker series rating requirements. Circuit breaker/circuit breaker series ratings are marked with the specific manufacturer's type circuit breakers while fuses are marked with the fuse industry class. That means when using circuit breaker/circuit breaker series ratings, there are no options to use a different manufacturer's circuit breaker. However, since the circuit breaker industry does not have "umbrella" circuit breakers, there is no provision for variance in the short circuit current let-through energies that might occur due to normal circuit breaker manufacturing tolerances.

Also, if a fuse/circuit breaker series combination is chosen, the designer or contractor has much greater flexibility to mix panelboard/switchboard manufacturers. For instance, the lighting panel could be from one manufacturer with that manufacturer's circuit breakers installed and the distribution panel equipped with switches can be from another manufacturer. However, if a circuit breaker/circuit breaker series combination is selected, then the lighting panelboard and distribution panelboard must come from the same manufacturer with their circuit breakers installed in both. There are no circuit breaker/circuit breaker series combinations that mix circuit breakers of different manufacturers.

Example of Practical Application of Series Rated Combination

See Figure 9. The 208Y/120V, 200 amp, lighting panel LDP1 has 25,000 amperes available short-circuit current. The distribution panel MDP1 has 45,000 amperes available. The lighting panel has all single pole, 20 amp circuit breakers. The typical standard 20 A lighting panel circuit breaker has a 10,000 ampere interrupting rating, which is insufficient for the 25,000A available. The options are (1) to use a higher interrupting rated circuit breaker for the lighting panel, which may cost more and require more space or (2) to use a series rated combination. The series rated combination option can be investigated by looking at the fuse/circuit breaker tables by panelboard manufacturer that follow at the end of this section.

Every major panelboard manufacturer has a suitable fuse/circuit breaker series rated solution. The example that follows uses Square D equipment, so review their table at the end of this section. The following is selected: Square D panelboard type NQOD with Square D QO single pole, 20 amp, circuit breakers (which have an individual interruption rating of 10,000 amperes) protected

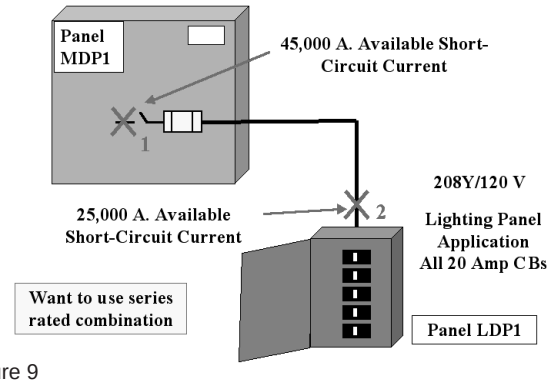


Figure 9

by Bussmann® LPJ-200SP Fuses (which have a 300,000 amp interrupting rating). From the table it is seen that this series combination interrupting rating is 200,000 amperes. That means if all the other requirements are met, these QO circuit breakers in this type panelboard can be applied in a system which has an available short-circuit current up to 200,000A at the point where the panelboard is installed. The requirements that must be met are:

1. The series combination interrupting rating must be equal to or greater than the available short-circuit current at the circuit breaker location, X_2. Remember, the load side circuit breaker in a series rated combination can be applied beyond its individual interrupting rating (a QO circuit breaker in this case has an individual interrupting rating of 10,000A).
2. In this example, the series rated combination interrupting rating is 200,000 amps and there is 25,000 amps available short-circuit current. The interrupting rating of the protecting overcurrent protective device must have an individual interrupting rating equal to or greater than the available short-circuit current at its point of application, X_1. In this example, the LPJ-200SP fuses have an individual interrupting rating of 300,000 amperes and there is 45,000 amps available short-circuit current available.
3. The load side (protected) circuit breaker's individual interrupting rating must meet the minimum required in 240.86(B) due to motor contribution. In this case, it is a lighting panel application and there are no motor loads on the load side of the LPJ-200SP fuses.
4. Selective coordination requirements. Selective coordination in this application is not required per the NEC® since this is neither a health care application, an elevator circuit nor a part of an emergency circuit. However, the owner and designer should consider the consequences of a lack of selective coordination. If selective coordination were considered to be necessary, another approach would have to be taken.
5. Labeling requirements. The panelboard must be marked by the manufacturer providing sufficient details about the listed series combination rating. The installer must field install a label on the panelboard and the distribution panelboard providing specific details of the installed series combination rating, the devices and their respective locations. These are critical for verifying the proper ratings for the initial installation and during the life of the system.

Tables by Manufacturer of Available Fuse / Circuit Breaker Series Combination Ratings on following pages:

Square D Series Rating Chart

I-Line Switchboard/Panelboard

(See Notes on Next Page)

Maximum System Voltage	SCIR*	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
240 Vac	100kA	LPN-RK	600	FH, KA, KH, LA, LH, MA, MH, MX	ALL	2, 3
		JJS	600	FA	ALL	2, 3
		JJS	800	FH, KA, KH, LA, LH, MA, MH, MX	ALL	2, 3
		LPJ	600	FA, FH, KA, KH, LA, LH, MA, MH, MX	ALL	2, 3
		KRP-C	800	KA	ALL	2, 3
		KRP-C	1200	FH, LA, LH	ALL	2, 3
		KRP-C	2000	KH, MA, MH, MX	ALL	2, 3
	200kA	LPN-RK	600	FH, FC, KH, KC, LA, LH, LC, LX, MA, MH, MX, NA, NC, NX	ALL	2, 3
		JJS	600	FA	ALL	2, 3
		JJS	800	FH, FC, KA, KH, KC, LA, LH, LC, LX, MA, MH, MX, NA, NC, NX	ALL	2, 3
		LPJ	600	FA, FH, FC, KA, KH, KC, LA, LH, LC, LX, MA, MH, MX, NA, NC, NX	ALL	2, 3
		KRP-C	800	FH, LA, LH	ALL	2, 3
		KRP-C	1200	FC, KH, KC, LC, LX, MA, MH, MX	ALL	2, 3
		KRP-C	2000	NA, NC, NX	ALL	2, 3
480 Vac	100kA	LPS-RK	600	FC, KA, KH, KC, LA, LH, LC, LX, MA, MH, MX, NA	ALL	2, 3
		JJS	600	FA, FH	ALL	2, 3
		JJS	800	FC, KA, KH, KC, LA, LH, LC, LX, MA, MH, MX, NA	ALL	2, 3
		LPJ	600	FA, FH, FC, KA, KH, KC, LA, LH, LC, LX, MA, MH, MX, NA	ALL	2, 3
		KRP-C	800	KA	ALL	2, 3
		KRP-C	1200	KH, LA, LH		
		KRP-C	1600	MA		
		KRP-C	2000	FC, KC, LC, LX, MH, MX, NA		
	200kA	LPS-RK	600	FC, KC, LA, LH, LC, LX, MA, MH, MX, NA, NC, NX	ALL	2, 3
		JJS	400	FA, FH	ALL	2, 3
		JJS	800	FC, KA, KH, KC, LA, LH, LC, LX, MA, MH, MX, NA, NC, NX	ALL	2, 3
		LPJ	400	FA, FH	ALL	2, 3
		LPJ	600	FC, KA, KH, KC, LA, LH, LC, LX, MA, MH, MX, NA, NC, NX	ALL	2, 3
		KRP-C	800	LA, LH	ALL	2, 3
		KRP-C	1200	FC, KC, LC, LX, MA, MH, MX	ALL	2, 3
		KRP-C	2000	NA, NC, NX	ALL	2, 3

*Series Combination Interrupting Rating

Square D Series Rating Chart

NQOD Panelboards

(See Notes Below)

Maximum System Voltage	SCIR*	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
240Vac	200kA	JJS, LPJ	200	QO, QOB	ALL	1, 2, 3
				QO, QOB (AS)	ALL	1, 2, 3
				QO, QOB (GF I)	ALL	1, 2, 3
		JJN	400	QO, QOB	ALL	1, 2, 3
				QO, QOB (AS)	ALL	1, 2, 3
				QO, QOB (GF I)	ALL	1, 2, 3

Note for NQOD Panelboards: 1P for use at 120V Only

NEHB Panelboards

(See Notes Below)

Maximum System Voltage	SCIR*	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
480Y/277Vac	100kA	JJS, LPJ	200	EH, EHB	ALL	1, 2, 3

Note for NEHB Panelboards: 1P for use at 277V Only

NF Panelboard

(See Notes Below)

Maximum System Voltage	SCIR*	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
480Y/277Vac	100kA	JJS, LPJ	400	EDB, EGB, EJB	ALL	1, 2, 3
	200kA	JJS, LPJ	200			

Note for NF Panelboards: 1P for use at 277V Only

SF Switchboards with I-Line or NQOD Distribution

(See Notes Below)

Maximum System Voltage	SCIR*	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
120/240Vac	42kA	JJS	400	QO-VH, QOB-VH	ALL	1 (120V)
240Vac	42kA	JJS	800	QO-VH, QOB-VH, FA, Q4	ALL	2, 3
				Q2-H	ALL	2
480Vac	50kA	JJS	800	FA, FH	ALL	2, 3
	65kA	JJS	800	KA, KH, LA, LH	ALL	

*Series Combination Interrupting Rating

NOTE (1): The data in these charts was compiled from information in Square D, Series Rating Data Bulletin No. 2700DB9901 and Square D Digest 171. Cooper Bussmann assumes no responsibility for the accuracy or reliability of the information. The information contained in the tables may change without notice due to equipment design modifications

NOTE (2): The line-side fused switch may be in a separate enclosure or in the same enclosure as the load-side circuit breaker. A line-side fused switch may be integral or remote.

NOTE (3): Max fuse current rating denotes the largest amperage fuse that may be used for that series rated combination. A lower amperage fuse may be substituted for the listed fuse.

Cutler-Hammer Series Rating Chart

Switchboards: PRL-C / PRL-i

Panelboards: PRL 5P, PRL 4, PRL 3A & Pow-R-Command Panelboards **(See Notes on Page 91)**

Max System Voltage	SCIR*	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
120/240	100kA	LPN-RK	200	GB, GHB	ALL	1,2
		JJN, LPJ	400	BA, BAB, HQP, QBHW, QPHW	ALL	1,2
	200kA	LPN-RK	100	BA, BAB, HQP, QBHW, QPHW, GB, GHB	ALL	1,2
		JJN, LPJ	200	BA, BAB, HQP, QBHW, QPHW	ALL	1,2
		JJN, LPJ	400	GB, GHB	ALL	1,2
240	100kA	LPN-RK	200	GHB	ALL	1,2,3
				GB, CA	ALL	2,3
		JJN, LPJ	400	BAB_H, QBHW_H, HQP_H, QPHW_H	ALL	2,3
		JJN	600	CA, CAH, HCA	ALL	2,3
		KRP-C	6000	EHD, FD	ALL	1,2,3
		KRP-C	6000	FDB, ED, JDB, JD, DK, KDB, KD	ALL	2,3
	200kA	LPN-RK	100	GHB	ALL	1,2,3
				BAB_H, QBHW_H, HQP_H, QPHW_H, CAH, HCA, GB	ALL	2,3
		LPN-RK	200	GB, GHB	ALL	2,3
		JJN, LPJ	200	BAB_H, HQP_H, QBHW_H, QPHW_H, CA, CAH, HCA	ALL	2,3
		JJN, LPJ	400	GHB	ALL	1,2,3
				GB	ALL	2,3
480/277	65kA	JJS, LPJ	200	GHBS	ALL	1,2
	100kA	JJS, LPJ	100	GHBS	ALL	1,2
		LPS-RK	200	GHB	ALL	1,2,3
		LPJ	600	EHD, FD, HFD, FDC	ALL	2,3
		JJS	600	GHB, EHD, FD, HFD, FDC, JD, HJD, JDC	ALL	2,3
	200kA	LPS-RK	100	GHB	ALL	1,2,3
		JJS, LPJ	400			
480	100kA	LPS-RK	100	EHD	ALL	2,3
		JJS, LPJ	200	EHD, FD, HFD,FDC	ALL	2,3
		KRP-C	1200	MC, HMC, NC, HNC	ALL	2,3
	200kA	KRP-C	800	MC, HMC	ALL	2,3
600	100kA	LPS-RK	100	FD, HFD	ALL	2,3
				FDC	ALL	2,3
			200	JD, HJD, JDC	ALL	2,3
			400	KD, HKD, KDC	ALL	2,3
			600	LC	ALL	2,3
		JJS, LPJ	200	FD, HFD	ALL	2,3
				FDC	ALL	2,3
			400	JD, HJD, JDC	ALL	2,3
		KRP-C	1200	LC	ALL	2,3
	200kA	LPS-RK	400	LC	ALL	2,3
		JJS, LPJ	600	KD, HKD, KDC, LC	ALL	2,3

*Series Combination Interrupting Rating

Cutler-Hammer Series Rating Chart

Panelboards: PRL 1A, PRL 2A, PRL 1A-LX, PRL 2A-LX **(See Notes Below & Page 91)**

Max System Voltage	SCIR*	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
120/240	100kA	LPN-RK	200	GB, GHB	ALL	1,2
		JJN, LPJ	400	BA, BAB, HQP, QBHW, QPHW	ALL	1,2
	200kA	LPN-RK	100	BA, BAB, HQP, QBHW, QPHW, GB, GHB	ALL	1,2
		JJN, LPJ	200	BA, BAB, HQP, QBHW, QPHW	ALL	1,2
		JJN, LPJ	400	GB, GHB	ALL	1,2
240	100kA	LPN-RK	200	GHB	ALL	1,2,3
				GB, CA	ALL	2,3
		JJN, LPJ	400	BAB_H, QBHW_H, HQP_H, QPHW_H	ALL	2,3
		JJN	600	CA, CAH, HCA	ALL	2,3
		KRP-C	6000	EHD, FD	ALL	1,2,3
		KRP-C	6000	FDB, ED, JDB, JD, DK, KDB, KD	ALL	2,3
	200kA	LPN-RK	100	GHB	ALL	1,2,3
				BAB_H, QBHW_H, HQP_H, QPHW_H, CAH, HCA, GB	ALL	2,3
		LPN-RK	200	GB, GHB	ALL	2,3
		JJN, LPJ	200	BAB_H, HQP_H, QBHW_H, QPHW_H, CA, CAH, HCA	ALL	2,3
		JJN, LPJ	400	GHB	ALL	1,2,3
				GB	ALL	2,3
480/277	65kA	JJS, LPJ	200	GHBS	ALL	1,2
	100kA	JJS, LPJ	100	GHBS	ALL	1,2
		LPS-RK	200	GHB	ALL	1,2,3
		LPJ	600	EHD, FD, HFD, FDC	ALL	2,3
		JJS	600	GHB, EHD, FD, HFD, FDC, JD, HJD, JDC	ALL	2,3
	200kA	LPS-RK	100	GHB	ALL	1,2,3
		JJS, LPJ	400			

*Series Combination Interrupting Rating

Notes for above Table:

1) The HQP & QPHW are not listed for use in the PRL1A-LX Panel.
2) PRL1A & PRL1A-LX are for use at 240V maximum
3) Branch breakers for maximum 120/240V systems include: BAB, HQP, QBHW & QPHW.
4) Branch breakers for maximum 240V systems include: BAB_H, HQP_H, QBHW_H & QPHW_H.
5) PRL2A & PRL2A-LX, branch breakers include: GHB, GHBS & GB.
6) PRL1A-LX & PRL2A-LX Main & Sub-feed breakers include: ED, FD, HFD, FDC.
7) PRL1A & PRL2A Main & Sub-feed breakers include: CA, CAH, HCA, ED, FD, HFD, FDC, JD, HJD, JDC, KD, HKD & KDC

Cutler-Hammer Series Rating Chart

Triple Series Rating - Switchboards: PRL-C & PRL-i
Panelboard Types: PRL 5P, PRL 4, PRL 3A, PRL 2A, PRL 2A-LX, PRL 1A, PRL 1A-LX & Pow-R-Command Panels **(See Notes Below)**

Max System Voltage	SCIR*	Line Side Fuse	Tenant Main Type	Branch Type		
				Circuit Breaker	Amps	Poles
120/240	100kA	KRP-C (Max Fuse Size - 6000A)	DK, KDB, KD	GB, GHB	ALL	1,2
			JD, JDB	GB, GHB	ALL	1,2
			FD	GB, GHB	ALL	1,2
			FD, FDB	HQP	15-70	1,2
				BA, BAB	ALL	1,2
			EHD	BA, BAB, HQP	ALL	1,2
240	100kA	KRP-C (Max Fuse Size - 6000A)	DK, KDB, KD	GHB	ALL	1,2,3
				GB, EHD	ALL	2,3
				CA, CAH, HCA	ALL	2,3
				FD, FDB	ALL	2,3
				JD, JDB	ALL	2,3
			JD, JDB	GHB	ALL	1,2,3
				GB	ALL	2,3
			FD	GHB	ALL	1,2,3
				GB	ALL	2,3
			FD, FDB	BAB_H, QBHW_H, HQP_H, QPHW_H	ALL	2,3
			EHD	BAB_H, HQP_H	ALL	2,3

*Series Combination Interrupting Rating

NOTE (1): The data in these charts was compiled from information in Cutler-Hammer, Series Rating Information Manual, catalog reference number 1C96944H01 Rev. E, pages 18-24, and Cutler-Hammer Consulting Application Catalog 12th Edition, pages F1-11 - F1-12. Cooper Bussmann assumes no responsibility for the accuracy or reliability of the information. The information contained in the tables may change without notice due to equipment design modifications.

NOTE (2): The line-side fused switch may be in a separate enclosure or in the same enclosure as the load-side circuit breaker. A line-side fused switch may be integral or remote.

NOTE (3): Max fuse current rating denotes the largest amperage fuse that may be used for that series rated combination. A lower amperage fuse may be substituted for the listed fuse.

GE Series Rating Chart

Spectra Series

(See Notes on Page 95)

Maximum System Voltage	SCIR*	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
240Vac	42kA	JJN, LPJ	600	TJD	250-400	2, 3
		KRP-C	2000	TJD	250-400	2, 3
	100kA	LPJ, JJN	400	TQD	125-225	2, 3
			600	THHQB	40-100	3
				TQD	100-225	2
				TQD	125-225	3
			800	TJD	250-400	2, 3
		KRP-C	1200	SFH	70-250	2, 3
			2000	TJD	250-400	2, 3
			2500	THJK	250-600	2, 3
	200kA	LPN-RK	200	TEB, TED	15-100	1, 2, 3
				SFH, SFL	70-250	2, 3
				SED, SEH, SEL	15-150	2, 3
		LPJ, JJN	400	TEB	15-100	1, 2
				TEB, TED	15-100	2, 3
				TJD	250-400	2, 3
				SFH, SFL	70-250	2, 3
			600	SED, SEH, SEL	15-150	2, 3
		KRP-C	2000	SGD, SGH, SGL	125-600	
277Vac	100kA	LPS-RK	100	TED	15-50	1
				THED	15-30	1
				TEY	15-100	1
			200	SED, SEH, SEL	15-150	2, 3
				TEY	15-100	1
				TED	15-50	1
		LPJ, JJS	400	TED	15-50	1
				THED	15-30	1
				SED, SEH, SEL	15-150	2, 3
			600	TEY	15-100	1
				SED, SEH, SEL	15-150	2, 3
480Vac	65kA	LPJ	600	TED, THED	15-150	2, 3
	100kA	LPS-RK	100	TED, THED6	15-100	2, 3
			200	TEY	15-100	2, 3
				SED, SEH, SEL	15-150	2, 3
				TED	15-50	1
		LPJ, JJS	400	TED, THED6	15-100	2, 3
				SFH, SFL	70-250	2, 3
				SGH, SGL	125-600	2, 3
			600	TEY	15-100	2, 3
				SED, SEH, SEL	15-150	2, 3
		JJS	800	SKH, SKL	300-1200	2, 3
		KRP-C	1200	THJK	125-600	2, 3
			2000	SKH, SKL	300-1200	2, 3
				SGH, SGL	125-600	2, 3
	200kA	KRP-C	2000	TPV, THPV	800A FRAME (1)	3
			2500	TPV, THPV	2500A FRAME (1)	3
600Vac	200kA	KRP-C	2000	TPV, THPV	800A FRAME (1)	3
			2500	TPV, THPV	2500A FRAME (1)	3

*Series Combination Interrupting Rating

(1) Includes all sensor/rating plug or setting values within stated frame size.

GE Series Rating Chart

AL / AQ PANELBOARD

(See Notes on Page 95)

Maximum System Voltage	SCIR*	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
240Vac	42kA	JJN	600	THQL-GF	15-30	1
				THQL	15-100 (2)	1, 2, 3
		JJN, LPJ	600	TJD	250-400	2, 3
		KRP-C	2000	TJD	250-400	2, 3
	65kA	JJN	600	THHQL	15-70	1
				THHQL	15-125	2
		JJN, LPJ, LPN-RK	600	TFJ	70-225	2, 3
		KRP-C	3000	TFJ	70-225	2, 3
	100kA	LPN-RK	200	THQL	15-100 (2)	1, 2, 3
		JJN	200	THQP	15-50	1, 2
		LPJ, JJN	400	THQL	15-100 (2)	1, 2, 3
				TQD	125-225	2, 3
			600	THHQL, THHQB	40-100	3
				TFJ	70-225	2, 3
				TQD	100-225	2
				TQD	125-225	3
			800	TJD	250-400	2, 3
		KRP-C	1200	TFJ	70-225	2, 3
				SFH	70-250	2, 3
			2000	TJD	250-400	2, 3
	200kA	LPN-RK	200	THQL	15-100 (2)	1, 2
				TFJ	70-200	2, 3
				SFH, SFL	70-250	2, 3
				SED, SEH, SEL	15-150	2, 3
		LPJ, JJN	400	THQL	15-100 (2)	1, 2
				TFJ	70-225	2, 3
				TJD	250-400	2, 3
				SFH, SFL	70-250	2, 3
			600	SED, SEH, SEL	15-150	2, 3
		KRP-C	2000	SGD, SGH, SGL	125-600	

(2) THQL 1 pole rating is 70 amperes maximum. Maximum system voltage is 120/240Vac.
THQL 2 pole 110-125A ratings are also series rated on 120/240Vac maximum services.

ALC / AQC Panelboard

(See Notes on Page 95)

Maximum System Voltage	SCIR*	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
240Vac	42kA	JJN	600	THQL-GF	15-30	1
				THQL	15-100 (2)	1, 2, 3
	65kA	JJN	600	THHQL	15-70	1
				THHQL	15-125	2
		JJN, LPJ, LPN-RK	600	TFJ	70-225	2, 3
		KRP-C	3000	TFJ	70-225	2, 3
	100kA	LPN-RK	200	THQL	15-100 (2)	1, 2, 3
		JJN	200	THQP	15-50	1, 2
		LPJ, JJN	400	THQL	15-100 (2)	1, 2, 3
				TQD	125-225	2, 3
			600	THHQL, THHQB	40-100	3
				TFJ	70-225	2, 3
				TQD	100-225	2
				TQD	125-225	3
		KRP-C	1200	TFJ	70-225	2, 3
				SFH	70-250	2, 3
	200kA	LPN-RK	200	THQL	15-100 (2)	1, 2
				TFJ	70-200	2, 3
				SFH, SFL	70-250	2, 3
				SED, SEH, SEL	15-150	2, 3
		LPJ, JJN	400	THQL	15-100 (2)	1, 2
				TFJ	70-225	2, 3
				SFH, SFL	70-250	2, 3
			600	SED, SEH, SEL	15-150	

*Series Combination Interrupting Rating
(2) THQL 1 pole rating is 70 amperes maximum. Maximum system voltage is 120/240Vac.
THQL 2 pole 110-125A ratings are also series rated on 120/240Vac maximum services.

GE Series Rating Chart

AE / AD PANELBOARD

(See Notes on Page 95)

Maximum System Voltage	SCIR*	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
277Vac	100kA	LPS-RK	100	TED	15-50	1
				THED	15-30	1
				TEY	15-100	1
			200	SED, SEH, SEL	15-150	2, 3
				TEY	15-100	1
				TED	15-50	1
		LPJ, JJS	400	TED	15-50	1
				THED	15-30	1
				SED, SEH, SEL	15-150	2, 3
			600	TEY	15-100	1
				SED, SEH, SEL	15-150	
480Vac	65kA	LPJ	600	TED, THED	15-150	2, 3
	100kA	LPS-RK	100	TED, THED6	15-100	2, 3
			200	TEY	15-100	2, 3
				SED, SEH, SEL	15-150	2, 3
				TED	15-50	1
		LPJ, JJS	400	TED, THED6	15-100	2, 3
				TFJ	70-225	2, 3
				TJJ	125-400	2, 3
				SFH, SFL	70-250	2, 3
				SGH, SGL	125-600	2, 3
			600	TEY	15-100	2, 3
				SED, SEH, SEL	15-150	2, 3
		JJS	800	SKH, SKL	300-1200	2, 3
		KRP-C	1200	TJJ	125-400	2, 3
			2000	SKH, SKL	300-1200	2, 3
				SGH, SGL	1	

*Series Combination Interrupting Rating

AEC PANELBOARD

(See Notes on Page 95)

Maximum System Voltage	SCIR*	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
277Vac	100kA	LPS-RK	100	TED	15-50	1
				TEY	15-100	1
			200	SED, SEH, SEL	15-150	2, 3
				TEY	15-100	1
				TED	15-50	1
		LPJ, JJS	400	TED	15-50	1
				SED, SEH, SEL	15-150	2, 3
			600	TEY	15-100	1
				SED, SEH, SEL	15-150	
480Vac	65kA	LPJ	600	TED	15-150	2, 3
	100kA	LPS-RK	100	TED	15-100	2, 3
			200	TEY	15-100	2, 3
				SED, SEH, SEL	15-150	2, 3
				TED	15-50	1
		LPJ, JJS	400	TED	15-100	2, 3
				TFJ	70-225	2, 3
				SFH, SFL	70-250	2, 3
				SGH, SGL	125-600	2, 3
			600	TEY	15-100	2, 3
				SED, SEH, SEL	15-150	

*Series Combination Interrupting Rating

GE Series Rating Chart

Note: The following circuit breakers may be substituted for the circuit breakers shown in the series rating tabulations. Devices with MicroVersaTrip Plus and PM trip units may also be substituted, provided the short circuit rating is equal to or greater than series connected rating. Ref. GE publication DET-008A.

Breaker	Substitute Breaker(s)
THQL	THQB, THQC, THQE, THHQL, THHQB, THHQC
THHQL	THHQB, THHQC
THQL-GF	THQB-GF, THQC-GF
TED	THED
SED	SEH, SEL, SEP
SEH	SEL, SEP
SEL	SEP
TQD	THQD
TFJ	TFK, THFK
SFH	SFL, SFP
SFL	SFP
TJJ	TJK, THJK, TJ4V, THJ4V, THJ9V, TJH
THJK	THJ4V, THJ9V, TJH, TJL
SGD	SGH, SGL, SGP
SGH	SGL, SGP
SGL	SGP
SKH	SKL, SKP
SKL	SKP
TPV	SS, SH, TP, TC, TCV, THP, THC, THCV
THPV	SH, THP, THC, THCV

NOTE 1: The data in these charts was compiled from information in GE Electrical Distribution & Control publication, catalog reference number GEP-1100P and GE Electrical Distribution & Control publication - UL Component Recognized Series Ratings, publication reference number DET-008A. Cooper Bussmann assumes no responsibility for the accuracy or reliability of the information. The information contained in the tables may change without notice due to equipment design modifications.

NOTE 2: The line-side fused switch may be in a separate enclosure or in the same enclosure as the load-side circuit breaker. A line-side fused switch may be integral or remote.

NOTE 3: Max fuse current rating denotes the largest amperage fuse that may be used for that series rated combination. A lower amperage fuse may be substituted for the listed fuse.

Siemens Series Rating Chart

Switchboards SB1, SB2, SB3
Panelboard S1

(See Notes on Next Page)

Max System Voltage	SCIR*	Line Side Fuse	Max Fuse Current Rating	Load side		
				Circuit Breaker	Amps	Poles
120/240Vac	65kA	LPJ, LPN-RK	600	QPH, BQH, BLH	15-70	1 (120V)
		JJN (300V)	1200		15-125	2
		KRP-C	6000		15-100	3
	100kA	JJN (300V)	200	QP, BQ, BL	15-70	1 (120V)
					15-125	2
					15-100	3
				HQP, HBQ, HBL, QPH, BQH, BLH	15-100	3
				QPF, BQF, BLF, QE, BE, BLE, QEH, BLEH, BLHF, QPHF, BQHF	15-30	1 (120V)
				QEH, BLEH, QE, QPHF, BLHF, BLE, QPF, BLF	15-60	2
				QT	15-50	1 (120V),2
			600	QPH, BQH, BLH, HQP, HBQ, HBL	15-70	1 (120V)
					15-125	2
					15-100	3
240Vac	100kA	LPJ, LPN-RK	600	ED4, HED4	15-100	1 (120V)
				ED4, ED6, HED4, HED6	15-125	2,3
				FD6-A, FXD6-A	70-250	2,3
				JD6-A, JXD6-A, JXD2-A, SJD6-A	200-400	2,3
				LD6-A	200-600	2,3
				SLD6-A	300-600	3
				LXD6-A	450-600	2,3
		JJN (300V)	1200	ED4, HED4	15-100	1 (120V)
				ED4, ED6, HED4, HED6	15-125	2,3
				FD6-A, FXD6-A	70-250	2,3
				JD6-A, JXD6-A, JXD2-A, SJD6-A	200-400	2,3
				LD6-A	200-600	2,3
				SLD6-A	300-600	3
				LXD6-A	450-600	2,3
		KRP-C	6000	ED4, HED4	15-100	1 (120V)
				ED4, ED6, HED4, HED6	15-125	2,3
				FD6-A, FXD6-A	70-250	2,3
				JD6-A, JXD6-A, JXD2-A, SJD6-A	200-400	2,3
				LD6-A	200-600	2,3
				SLD6-A	300-600	3
				LXD6-A	450-600	2,3
				SMD6	500-800	3
				SND6	500-1200	3
				PD6, PXD6, SPD6	1200-1600	3
				RD6, RXD6	1600-2000	3
	200kA	LPN-RK	200	QJH2, QJ2H, QJ2	125-200	2,3
		JJN (300V) LPJ	400	QJ2	125-225	2,3
			600	QJH2, QJ2H	125-225	2,3
		LPJ, LPN-RK	600	HFD6, HFXD6	70-250	2,3
		JJN (300V)	1200	HFD6, HFXD6	70-250	2,3
		KRP-C	6000	HFD6, HFXD6	70-250	2,3
				MD6, MXD6, HMD6, HMXD6	500-800	2,3
				ND6, NXD6, HND6, HNXD6	500-1200	2,3

*Series Combination Interrupting Rating

Siemens Series Rating Chart

Switchboards SB1, SB2, SB3
Panelboards S2, SE, S3, S4, S5 **(See Notes Below)**

Max System Voltage	SCIR*	Line Side Fuse	Max Fuse Current Rating	Load side		
				Circuit Breaker	Amps	Poles
480Vac	50kA	LPJ	400	ED4	60-100	1 (277V)
					15-100	2,3
	100kA	LPJ	400	ED4	15-50	1 (277V)
		JJS, LPJ	600	FD6-A, FXD6-A	70-250	2,3
		LPJ, LPS-RK	600	HFD6, HFXD6	70-250	2,3
		JJS, LPJ, LPS-RK	600	JD6-A, JXD6-A, HJD6-A, HJXD6-A	200-400	2,3
				LD6-A, HLD6-A	200-600	2,3
				LXD6-A, HLXD6-A	450-600	2,3
		JJS	800	HFD6, HFXD6	70-250	2,3
		JJS, KRP-C	1200	JD6-A, JXD6-A, HJD6-A, HJXD6-A	200-400	2,3
				LD6-A, HLD6-A	200-600	2,3
				LXD6-A, HLXD6-A	450-600	2,3
		KRP-C	6000	HFD6, HFXD6	70-250	2,3
				MD6, MXD6, HMD6, HMXD6	500-800	2,3
				ND6, NXD6, HND6, HNXD6	500-1200	2,3
480/277V	200kA	LPS-RK	100	BQD, CQD	15-100	1 (277V)
				BQD**, CQD **	20-30	2,3
		JJS, LPJ	200	BQD, CQD	15-100	1 (277V)
				BQD**, CQD **	20-30	2,3

*Series Combination Interrupting Rating

** BQD and CQD breakers are series rated from 15-100A for Series 7A, S2 and S3 panelboard applications only.

NOTE (1): The data in these charts was compiled from information in Siemens SpeedFax 2000 Electrical Products publication, catalog reference number GNPC-01000. Cooper Bussmann assumes no responsibility for the accuracy or reliability of the information. The information contained in the tables may change without notice due to equipment design modifications.

NOTE (2): The line-side fused switch may be in a separate enclosure or in the same enclosure as the load-side circuit breaker. A line-side fused switch may be integral or remote.

NOTE (3): Max fuse current rating denotes the largest amperage fuse that may be used for that series rated combination. A lower amperage fuse may be substituted for the listed fuse.

Series Combination Rating Requirements

by Tim Crnko

Series combination ratings are utilized to attempt to save money on some jobs. This article presents a simple checklist that can be completed by the contractor and/or designer when series rated combinations are proposed. The checklist is designed to be a single sheet that is double sided [checklist can be found on pages fifteen and sixteen]. The front side requires information for a specific series rated application. The backside provides an easy reference of general application information and provides the specific *National Electrical Code* requirements. In the plan review stage, the checklist provides the AHJ the necessary information to review series combinations in their specific application. During the inspection phase of the installation, the AHJ can use this checklist as a guide to confirm compliance with the design and proper installation requirements.

Why the Checklist?

There is confusion in the industry on the requirements of properly applying and installing series combination ratings. What combinations are suitable? In the specific building installation, is the series combination rating greater than the available short-circuit current? Is the motor contribution within allowable limits? Is the panelboard or switchboard properly marked by the manufacturer for the series combination rated devices that are to be used? Has the installer properly affixed the required field markings? Are there selective coordination requirements that would not permit using series rated combinations? If these questions are not investigated and found to be acceptable for a specific application, then the series rated combination cannot be used. After a job is designed with fully rated fuses or circuit breakers, sometimes the job is value engineered and series rated combinations are proposed for portions of the system. It is important to insure that the design still meets the *NEC*. This checklist can help that process.

Fully Rated System

A fully rated system is one in which all of the overcurrent protective devices have an individual interrupting rating equal to or greater than the available short-circuit current at their line terminals. This is a requirement in 110.9. Fully rated systems can consist of all fuses, all circuit breakers, or a combination of fuses and circuit breakers (see figures 1 and 2).

Series Rated

Series rated is a combination of circuit breakers or fuses and circuit breakers that can be applied at available short-circuit levels above the interrupting rating of the load side (protected) circuit breaker, but not above the interrupting rating of the main or line-side device. A series rated combination can consist of fuses protecting circuit breakers, or circuit breakers protecting circuit breakers. It is very important to note that with a series rated combination there is an allowance per 240.86 to permit application of a load side (protected) circuit breaker beyond its individual interrupting rating. Figure 3 illustrates a fuse/circuit breaker series rated combination. Figure 4 illustrates a circuit breaker/circuit breaker series rated combination.

Which Is Best: Fully Rated or Series Rated?

From an inspection perspective, the first priority is

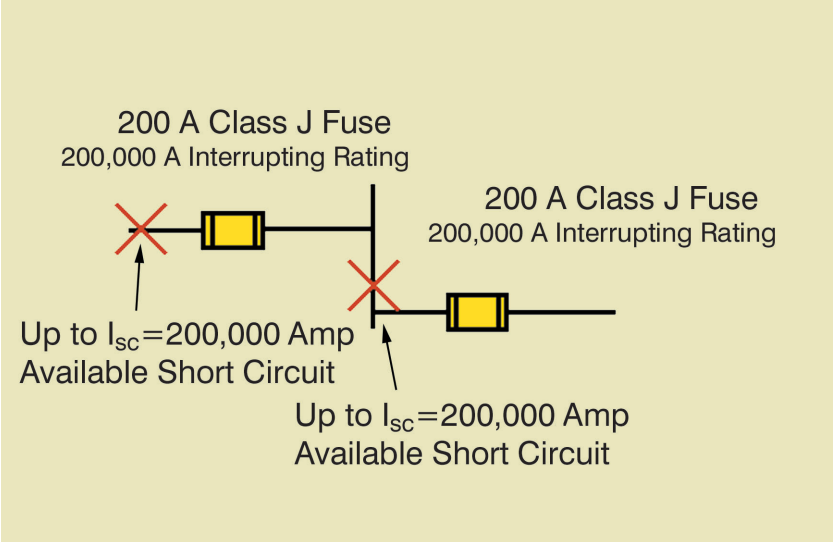


Figure 1. Fully Rated Fuse System

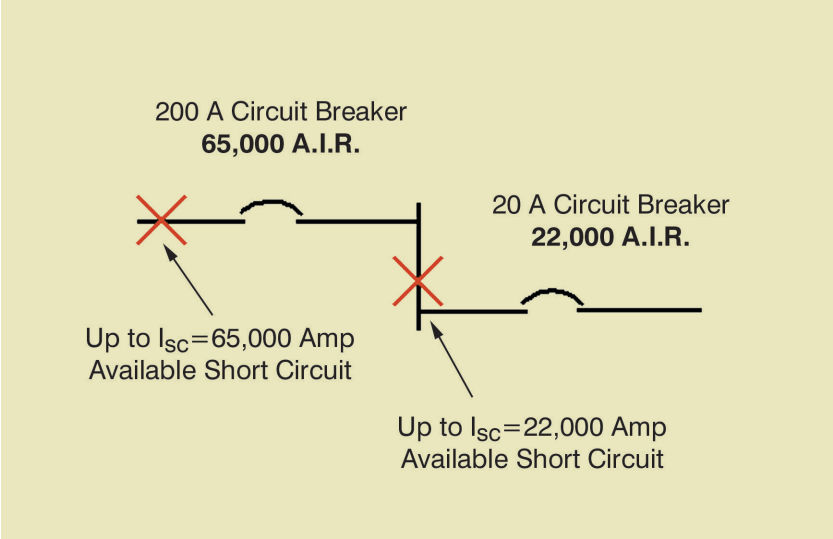


Figure 2. Fully Rated CB System

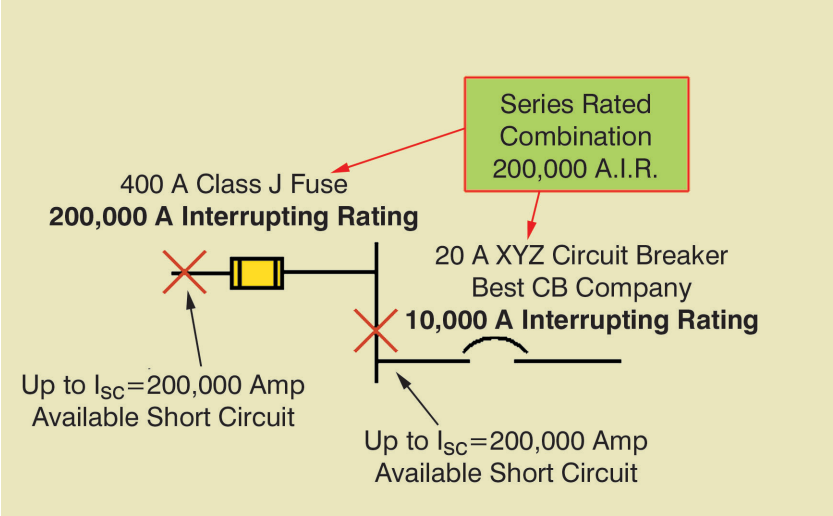


Figure 3. Series Rated System Fuse/CB

to focus on compliance to 110.9. The most suitable application for series rated combinations is for branch circuit, lighting panel circuit breakers. With a series rated combination, the load side circuit breaker is applied beyond its individual interrupting rating. Because of this, if a series rated combination is to be used, the designer and contractor should select the tested, listed and marked line-side protection that will assure reliable performance over the lifetime of the electrical system. If the line-side protecting overcurrent protective device does not react as intended due to lack of maintenance or loss of calibration, the load-side circuit breaker may be on its own to interrupt. Although series rated combinations save a small percentage of the initial equipment costs, there are many issues about designing and utilizing series rated combinations. However, that is another article topic targeted at the designers and contractors. This article is focused on the *NEC* compliance requirements for series rated combinations.

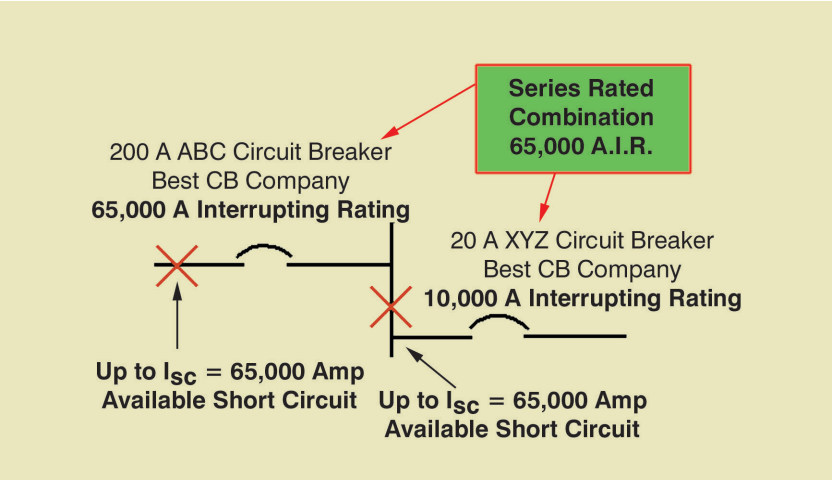


Figure 4. Series Rated System CB/CB

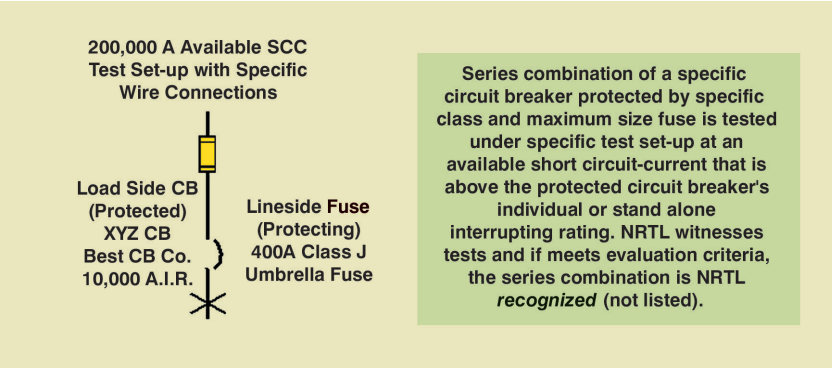


Figure 5. Series Combination Recognition Testing

How Is A Series Rated Combination Listed?

A nationally recognized testing laboratory (NRTL) does not list a fuse/circuit breaker or circuit breaker/circuit breaker series combination by itself. The listing for a series combination has to be evaluated and found suitable for a specific manufacturer's panelboard, loadcenter or switchboard line.

Basically, it works like this. A specific type circuit breaker (XYZ) by Best CB Company is tested as the load-side (protected) circuit breaker with a specific line-side (protecting) overcurrent protective device, which can be either a circuit breaker or fuse. For instance in figure 3, the 20-amp XYZ circuit breaker by Best CB Company is tested with a 400-amp Class J fuse (a special umbrella fuse is used to insure the let-through represents the 400 A Class J fuses as made by all manufacturers). The short-circuit test is at 200,000 amperes even though the XYZ circuit breaker has an interrupting rating of 10,000 amperes. Based on UL 489, Standard for Molded-Case Circuit Breakers, if the circuit breaker passes the evaluation criteria, the combination of a 400-amp Class J fuse and the 20-amp XYZ circuit breaker manufactured by Best CB Company is filed by the NRTL as only a recognized series rated combination (see figure 5). However, this is not a listing, further evaluation is necessary.

To be useful, the panelboard or switchboard manufacturer (XYZ Panelboard Manufacturing Company) must have their equipment tested, evaluated and listed by a NRTL using the recognized combination in their panelboard or switchboard (see figure 6).

If this recognized series combination passes the NRTL's evaluation, then this series combination of load-side 20-amp XYZ circuit breaker by Best CB Company and line-side 400-amp Class J fuses is marked on that specific manufacturer's style panelboard or switchboard (referred to as tested, listed and marked). The load-side (protected) circuit breaker would be installed in that panelboard or switchboard. The line-side (protecting) Class J fuses, up to 400 A, could be in that panelboard or switchboard or in another upstream panelboard or switchboard. And now the XYZ circuit breaker manufactured by Best CB Company, which has a 10,000 A interrupting rating, installed in XYZ Panelboard with the series rated combination mark, can be applied on a system with 200,000 amperes available short-circuit current (see figure 7). That is, if other *NEC*® requirements are met! These other requirements are extremely important to make sure a series rated combination is, in fact, applied per its testing, listing and marking [110.3(B)].

What Other Requirements Must Be Met?

240.86(A) Factory Labeling Requirement. The process of testing, listing and marking a series rated combination was just covered. Section 240.86(A) requires that, when a series rated combination is used, the switchboard or panelboard be listed and *factory marked* for use with the series rated combinations to be utilized. Often there is not enough room in the equipment to show all of the legitimate series rated combinations. So UL 67, Panelboards, allows for a booklet to be referenced and supplied with the panelboard. The booklet is to be affixed to the panelboard. These booklets typically provide all of the acceptable combinations for the panelboard. This provides evidence that a switchboard or panelboard is listed up to a specified available short-circuit current for a specific series combination in that specific panelboard or switchboard. For a specific job, the AHJ must be provided data to demonstrate that the series rated combination has an adequate series (interrupting) rating for the available short-circuit current at the installation point of the load side (protected) circuit breaker. See figure "110.22 & 240.86(A) Labeling" on the second page of the checklist at the end of this article.

110.22 Field Labeling Requirement

This section places responsibility on the *installer* (electrical contractor) to *affix labels* on the equipment enclosures, which note the interrupting rating of the series rated combination and call out the specific replacement overcurrent protective devices to be utilized. If the upstream overcurrent protective device protecting the downstream circuit breaker is in a different enclosure, then both enclosures need to have field-installed labels affixed and call out the other location on the labels. See figure labeled "110.22 & 240.86(A) Labeling" on the second page of the checklist at the end of this article.

This field marking is critical for ensuring that proper devices are installed as initially intended and properly replaced years later. It becomes absolutely necessary when replacement of fuses or circuit breakers is needed; this field marking helps ensure that the original system design integrity is maintained. If the wrong replacement circuit breaker is used on the load side or line side or the wrong fuse is used on the line side, the series rating is no longer valid. This could result in a serious fire and safety hazard.

These labeling requirements are also very important for evaluating the suitability of this equipment, if at a future date the electrical system is changed or upgraded. Proper labeling per 240.86(A) and 110.22

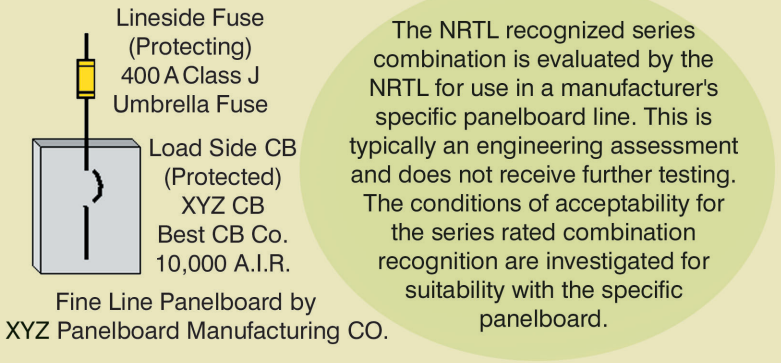


Figure 6. Series Combination Evaluated for Panelboard

provides a means to assess the suitability of the series rated combination when the electrical system parameters later change due to a refurbishment or other system change. The owners or maintenance contractors should maintain these labels throughout the life of the equipment. When electrical system upgrades occur, without this labeling affixed to the equipment, the owner most often must needlessly throw out the existing equipment and buy new equipment.

240.86(B) Motor Contribution Limitations

Where motors are connected between the line-side (protecting) device and the load-side (protected) circuit breaker, 240.86(B) has a critical limitation on the use of series rated combinations. This section requires that a series rated combination shall not be used where "the sum of *motor full-load currents exceeds 1 percent of* the" *load side (protected) circuit breaker's individual "interrupting rating*" [italics added.] The rea-

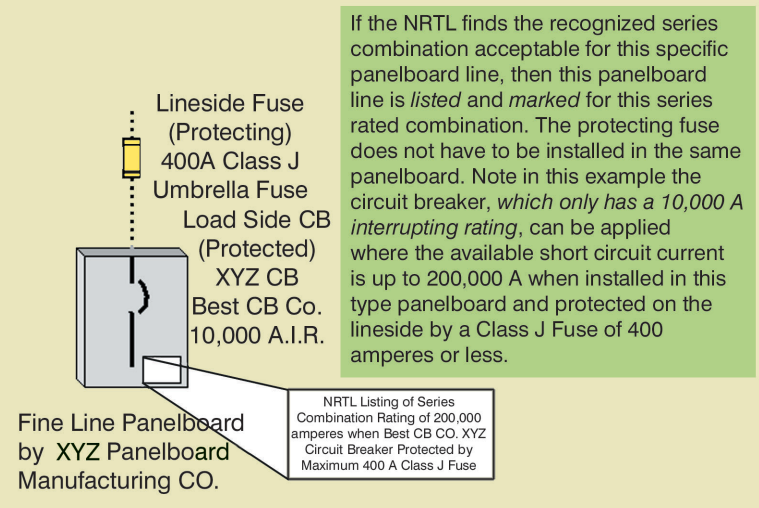


Figure 7. Series Rated Combination NRTL Listed with Panelboard

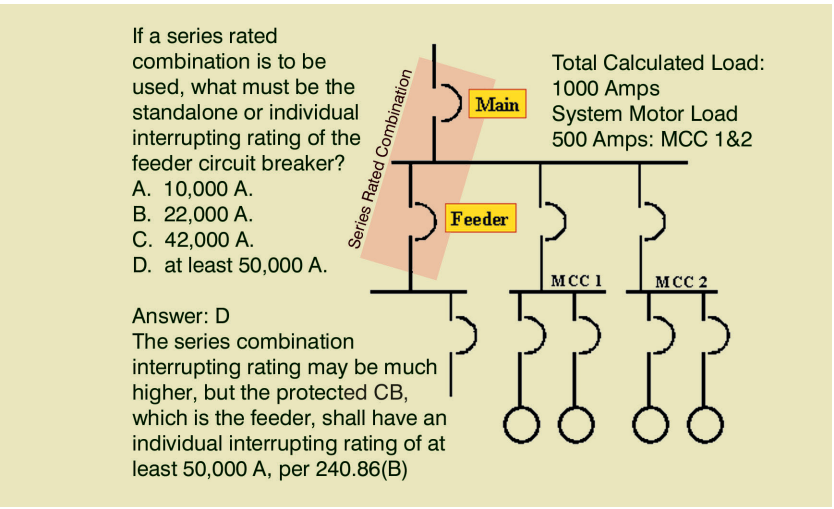


Figure 8. Motor Contribution Limitations of Series Combinations

son is that when a fault occurs, running motors momentarily contribute current to the short-circuit (usually about four to six times their rating). This added motor contribution could result in a short-circuit current in excess of what the load-side (protected) circuit breaker was tested to handle per the series rated combination testing, listing and marking. See the figure on motor contribution on the second page of the checklist at the end of this article.

This is one of the major reasons that series rated combinations are generally recommended only for lighting panel applications. Lighting panels generally do not have significant motor loads so the motor contribution is typically not an issue. However, series rated combinations used for power panel or main/feeder applications can pose a problem upon initial installation or if the loads change in the future. On a new installation with a 1000-A service load containing 50 percent motor load (which is motor full load amperes of 500), the motor contribution could be an issue in selecting a series rated combination. If a main/feeder series rating were to be considered, the feeder could require at least a 50,000-A individual or stand-alone interrupting rating (1 percent of 50,000 = 500). See figure 8 to illustrate this example.

Then consider the uncertain future of building spaces. For instance, many building spaces by their nature inherently incur future changes, such as strip malls, enclosed malls, business park buildings, manufacturing facilities, many institutional buildings, and many commercial spaces. A properly designed and initially installed series rating could be negated if the building loads change to significantly higher motor loads.

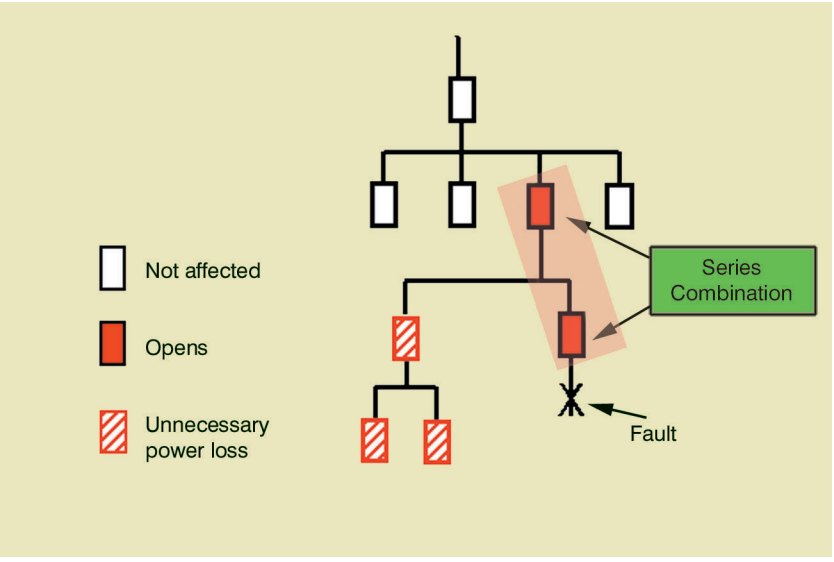


Figure 9. Selective Coordination Limitations of Series Combinations

Selective Coordination Requirement Limitations

Inherently, series rated combinations cannot be selectively coordinated. The line-side (protecting) device must open at the same time and in conjunction with the load-side (protected) circuit breaker. This means that the entire panel loses power because the device feeding the panel must open under medium- to high-level short-circuit and ground-fault conditions.

Therefore, in health care facilitates where selective coordination of ground-fault protection is required between the main and feeders, series rated combinations do not meet the 517.17 requirements. Also, series rated combinations do not meet the selective coordination requirement for elevator circuits per 620.62 where there are two or more elevators. Series rated combinations reduce emergency circuit overall system reliability as presented in the 700.25 FPN because of their limitation of fault current coordination (see figure 9).

In summary, there are specific *NEC* requirements that shall be met by the designer and installer if series rated combinations are to be used. At the end of this article is a two-page checklist that can be copied onto one double-sided sheet. The AHJ may require the designer and/or contractor to complete this checklist if a series rated combination is to be used. An electronic copy of this checklist can be downloaded from www.bussmann.com under "Application Info / NEC®/IAEI Information."

Tim Crnko, training & technical services manager for Cooper Bussmann, has MSEE and is a member of IAEI, IEEE and NFPA. tcrnko@buss.com

INSPECTION FORM: Series Rated Combination

ISSUED BY: _____

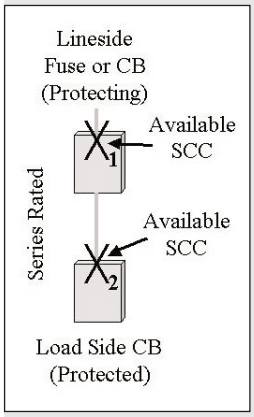
This form provides documentation to assure compliance with the following National Electrical Code®, NFPA 70, sections on the use of Series Rated Combinations: **110.9, 110.22 & 240.86**

JOB # _____

NAME: _____

LOCATION: _____

CONTRACTOR: _____



ESSENTIAL INFORMATION:

Line Side Panel Designation (If applicable) _____

Line Side Overcurrent Protective Device Part Number _____

Line Side Overcurrent Protective Device Interrupting Rating _____

X_1 Available Short Circuit Current at Line side OCP Device _____

Load Side Panel Designation _____

Load Side Circuit Breaker Part Number _____

Load Side Circuit Breaker Individual Interrupting Rating _____

Series Combination Interrupting Rating _____

X_2 Available Short Circuit Current at Load side Circuit Breaker _____

Compliance Checklist

(For further information see discussion on reverse side for each item)

1. Short-Circuit Currents

Is the interrupting rating of the line side fuse or circuit breaker greater than the available short-circuit current (X_1) at its lineside (110.9) ❑ YES ❑ NO

Is the series combination interrupting rating greater than the available short-circuit current (X_2) at the load side circuit breaker (permitted per 240.86)? ❑ YES ❑ NO

2. Manufacturer's Label

Are both devices in use for the series rated combination marked on the end use equipment in which the load side circuit breaker is installed (or contained in a booklet affixed to the equipment) as required in 240.86(A)? ❑ YES ❑ NO

3. Field Installed Label

Are field labels, as required by 110.22, that indicate "CAUTION – Series Rated Combination", along with the required replacement parts, panel designations, and series combination interrupting rating, installed on all end use equipment that contain the series combination rating devices? ❑ YES ❑ NO

4. Motor Contribution

If motors are connected between the series rated devices, is the combined full load current from these motors less than 1% of the downstream circuit breakers' interrupting rating (individual or stand alone interrupting rating) per 240.86(B)? ❑ YES ❑ NO

5. Selective Coordination

Is this series rated combination being installed in something other than a health care facility (see NEC® 517.17)? ❑ YES ❑ NO

Elevator circuits only: Is this series rated combination being installed on an elevator circuit with only one elevator in the building (see NEC® 620.62)? ❑ YES ❑ NO

AN ANSWER OF "NO" TO ANY OF THESE QUESTIONS MAY INDICATE A LACK OF COMPLIANCE. LACK OF SUBMITTAL IS CONSIDERED AS EVIDENCE OF LACK OF COMPLIANCE.

Series Rated Combination

What is a Series Rated Combination?

A combination of two devices, that have been tested under specific test conditions that work together to clear a fault. The allowed combinations are limited to those that have been selected by the circuit breaker manufacturer for testing. Only tested combinations can be used.

CAUTION: A series rated combination allows a load side circuit breaker to be applied where the available short circuit current exceeds the interrupting rating marked on that circuit breaker.

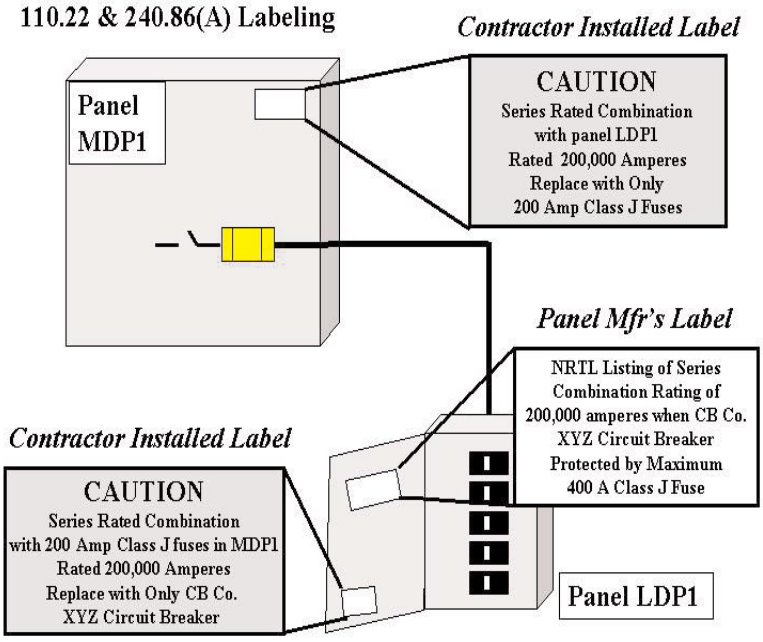
BACKGROUND TO CHECKLIST ITEM

1) Short-Circuit Currents

The series combination interrupting rating must be greater than the available short-circuit current at the load side circuit breaker (240.86) and the interrupting rating of the line side fuse or circuit breaker must be greater than the available short-circuit current at its line terminals (110.9).

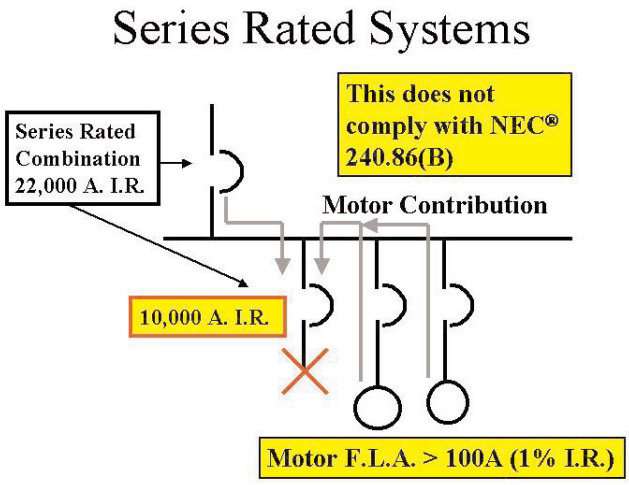
2) Manufacturer's Label

Since the use of series rated combinations are limited to specific combinations that have been tested, the end use equipment is required to be marked, by the **manufacturer**, per 240.86(A) of the 2002 NEC®. Since there are hundreds of combinations, this marking may be in a book that is affixed to the end use equipment, as allowed in UL67. The manufacturer's marking is used to verify that both devices are part of a recognized series rated combination, the panelboard is listed for use with the combination, and that the series combination interrupting rating is sufficient for the available short circuit current. This label also provides guidance for future upgrades as to the specific replacement devices that are allowed.



3) Field Installed Label

110.22 of the 2002 NEC" requires the **installer** to apply a field caution label warning that a series rated combination is being used. This label must be applied on the panel containing the series rated combination or on both pieces of electrical equipment if the line side device is located separate from the load side circuit breaker to assure that the proper devices have been installed and that proper future replacements are made. The inspector can check the devices noted on the field label required by 110.22 against the tested and listed series rated combinations marked on the panelboard or switchboard by the manufacturer per 240.86.



4) Motor Contribution

A series rated combination is evaluated under specific testing conditions of which motor contribution is not a part of the criteria. If a motor(s) were connected in the middle of the combination, it would supply extra fault current that did not exist when the combination was tested. 240.86(B) of the 2002 NEC® addresses this by prohibiting the use of series rated combinations when the sum of the full load current of the motors exceeds 1% of the interrupting rating marked on the **LOAD SIDE** circuit breaker. For example, if the load side circuit breaker is rated 10,000 A.I.R., with motor loads exceeding 100 amps, then a series rated combination could not be used. For other than lighting panels, it is necessary to investigate the protected circuit breaker of a series combination to insure that the protected circuit breaker's individual interrupting rating complies with 240.86(B). For other than lighting panels, it is advisable not to utilize series rated combinations for building spaces where the loads may change during the life of the electrical system. If more motor loads are added, the series combination rating for that application could be negated.

5) Selective Coordination

A disadvantage of a series rated combination is that, by definition, for fault conditions the line side (protecting) device must open at the same time, and in conjunction with, the load side (protected) circuit breaker. This means that the entire panel loses power because the device feeding the panel must open under medium to high level short-circuit conditions. For life and safety reasons, the NEC® requires selective coordination in some applications. Main to feeder series rated combinations do not meet the requirements of 517.17 in health care facilities. Series rated combinations do not meet 620.62 for elevator circuits that contain more than one elevator. Series rated combinations would reduce the overall system reliability of emergency circuits as presented in 700.25 FPN because of their inherent lack of fault current coordination.

PREVENTATIVE MAINTENANCE AND RELIABILITY OF LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES

Michael Callanan
National Joint Apprenticeship and Training Committee
301 Prince George's BLVD, Suite D
Upper Malboro, MD 20774

Dennis K. Neitzel, CPE (M. IEEE)
AVO Training Institute
4271 Bronze Way
Dallas, Texas 75237

Dan Neeser (M. IEEE)
Cooper Bussmann
PO Box 14460
St. Louis, MO 63178-4460

Abstract – Electrical preventative maintenance and testing is one of the most important aspects to assure the reliability and integrity of electrical distribution systems, as well as the protection of equipment and people. However, preventative maintenance of electrical systems and equipment, specifically with regard to overcurrent protective devices, is often overlooked or performed infrequently.

This paper will explore:

- Guides for electrical equipment and low voltage overcurrent protective device maintenance and testing.
- Analysis of various electrical equipment installations and the maintenance program for low voltage overcurrent protective devices practiced.
- Failure statistics for low voltage overcurrent protective devices
- The reliability and integrity of low voltage overcurrent protective devices.
- Arc flash hazards with respect to preventative maintenance of low voltage overcurrent protective devices.

I. INTRODUCTION

The *National Electrical Code* states "Overcurrent protection for conductors and equipment is provided to open the circuit if the current reaches a value that will cause an excessive or dangerous temperature in conductors or conductor insulation." [7]

With regard to circuit breakers, the only way to accomplish this is through proper maintenance and testing of these devices. Several studies have revealed that if a circuit breaker has not been maintained, according the manufacturers' instructions, for a period of five years, there is a 50% probability of failure of the circuit breaker.

The first step to properly maintaining electrical equipment and overcurrent protective devices is to understand and practice recommendations of electrical equipment maintenance from various sources. Examples of sources that could be used for this purpose include, but are not limited to, NFPA 70B, IEEE Standard 902 (Yellow Book), NEMA AB-4, NETA Specs, NFPA 70E-2000, and the Manufacturer's instructions, as well as any applicable IEC standards.

II. ELECTRICAL EQUIPMENT AND OVERCURRENT PROTECTIVE DEVICE MAINTENANCE AND TESTING

A. Qualified Employees

The first step in the maintenance and testing of overcurrent protective devices is to provide adequate training and qualification for employees. NFPA 70E states "Employees who perform maintenance on electrical equipment and installations shall be qualified persons…and shall be trained in and familiar with the specific maintenance procedures and tests required." [6]

The basic definition of a qualified person is one that is familiar with the construction and operation of the equipment and the hazards involved. The Occupational Safety and Health Administration (OSHA) also requires an employee to demonstrate proficiency in the work practices involved before the employer can certify that they have been trained. It is vitally important that an employee be properly trained and qualified to maintain electrical equipment in order to increase the equipment and systems reliability, as well as the employee's safety.

B. Electrical Preventive Maintenance Program

NFPA 70E also states "Protective devices shall be maintained to adequately withstand or interrupt available fault current." It goes on to state, "Circuit breakers that interrupt faults approaching their ratings shall be inspected and tested in accordance with the manufacturers' instructions." [6]

The second step is to have an effective Electrical Preventive Maintenance (EPM) program. NFPA 70B makes several very clear statements about an effective EPM program as follows:

- "Electrical equipment deterioration is normal, but equipment failure is not inevitable. As soon as new equipment is installed, a process of normal deterioration begins. Unchecked, the deterioration process can cause malfunction or an electrical failure. Deterioration can be accelerated by factors such as a hostile environment, overload, or severe duty cycle. An effective EPM program identifies and recognizes these factors and provides measures for coping with them. "
- "In addition to normal deterioration, there are other potential causes of equipment failure that can be detected and corrected through EPM. Among these are load changes or additions, circuit alterations, improperly set or improperly selected protective devices, and changing voltage conditions."
- "Without an EPM program, management assumes a greatly increased risk of a serious electrical failure and its consequences."

- "A well-administered EPM program will reduce accidents, save lives, and minimize costly breakdowns and unplanned shutdowns of production equipment. Impending troubles can be identified — and solutions applied — before they become major problems requiring more expensive, time consuming solutions." [1]

IEEE Std 902 states: "In planning an electrical preventive maintenance (EPM) program, consideration must be given to the costs of safety, the costs associated with direct losses due to equipment damage, and the indirect costs associated with downtime or lost or inefficient production." [2]

Another issue that also must be discussed is the Flash Hazard Analysis. One of the key components of this analysis is the clearing time of the overcurrent protective devices. The primary focus of this paper will be low-voltage circuit breakers. Fuses, although they are overcurrent protective devices, do not have operating mechanisms that would require periodic maintenance and testing to assure proper overcurrent operation; therefore, they will not be addressed in this paper. The primary focus of this paper is the maintenance issues associated with circuit breakers. Thus, whether concerned with the proper protection of equipment or of personnel, periodic maintenance and testing is essential. All maintenance and testing of electrical protective devices addressed here must be accomplished in accordance with the manufacturer's instructions. In the absense of the manufacturer's instructions, the NETA *Maintenance Testing Specifications for Electrical Power Distribution Equipment and Systems* is an excellent source of information for performing the required maintenance and testing of these devices. The manufacturer's time-current curves would also be required in order to properly test each protective device.

Similar to NFPA 70B and NETA, the IEC standards also indicate the need for maintenance of circuit breakers. For instance, with regards to low voltage circuit breakers, IEC 60947-2 *Low Voltage Switchgear and Controlgear - Part 2: Circuit Breakers*, Section 5.3 Instructions for installation, operation and maintenance the user is reffered to Subclause 5.3 of Part 1.

In IEC 60947-1 *Low Voltage Switchgear and Controlgear - Part I: General Rules*, Section 5.3 Instructions for installation, operation and maintenance requires:

- The manufacturer shall specify in his documents or catalogues the conditions, if any, for installation, operation and maintenance of the equipment during operation and after a fault, and the measures to be taken with regard to the equipment, if any, concerning EMC.
- These documents shall indicate the recommended extent and frequency of maintenance, if any.

1) Molded-Case Circuit Breakers: The need for inspection of molded case breakers will vary depending on operating conditions. Suggested inspection and testing is defined in ANSI/NEMA AB 4, *Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications*. As part of these guidelines, AB 4 also provides some basic procedures for the inspection and maintenance of molded-case circuit breakers, by qualified persons.

Generally, maintenance on molded-case circuit breakers is limited to proper mechanical mounting, electrical connections, and periodic manual operation. Most lighting, appliance, and power panel circuit breakers have riveted frames and are not designed to be opened for internal inspection or maintenance. All other molded-case circuit breakers, that are UL approved, are factory-sealed to prevent access to the calibrated elements. An unbroken seal indicates that the mechanism has not been tampered with and that it should function as specified by UL. A broken seal voids the UL listing and the manufacturers' warranty of the device. In this case, the integrity of the device would be questionable. The only exception to this would be a seal being broken by a manufacturer's authorized facility.

Molded-case circuit breakers receive initial testing and calibration at the manufacturers' plants. These tests are performed in accordance with UL 489, *Standard for Safety, Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures*. Molded-case circuit breakers, other than the riveted frame types, are permitted to be reconditioned and returned to the manufacturer's original condition. In order to conform to the manufacturer's original design, circuit breakers must be reconditioned according to recognized standards. An example of a recognized standard is the Professional Electrical Apparatus Recyclers League (PEARL) Reconditioning Standards. In order to ensure equipment reliability it is highly recommended that only authorized professionals recondition molded-case circuit breakers.

Circuit breakers installed in a system are often forgotten. Even though the breakers have been sitting in place supplying power to a circuit for years, there are several things that can go wrong. The circuit breaker can fail to open due to a burned out trip coil or because the mechanism is frozen due to dirt, dried lubricant, or corrosion. The overcurrent device can fail due to inactivity or a burned out electronic component. Many problems can occur when proper maintenance is not performed and the breaker fails to open under fault conditions. This combination of events can result in fires, damage to equipment, or injuries to personnel.

Common sense, as well as manufacturers' literature, must be used when maintaining circuit breakers. Most manufacturers, as well as NFPA 70B, recommend that if a molded-case circuit breaker has not been operated, opened or closed, either manually or by automatic means, within as little as six months time, it should be removed from service and manually exercised several times. This manual exercise helps to keep the contacts clean, due to their wiping action, and ensures that the operating mechanism moves freely. This exercise however does not operate the mechanical linkages in the tripping mechanism (Figure 1). The only way to properly exercise the entire breaker operating and tripping mechanisms is to remove the breaker from service and test the overcurrent and short-circuit tripping capabilities. A stiff or sticky mechanism can cause an unintentional time delay in its operation under fault conditions. This could dramatically increase the arc/flash incident energy level to a value in excess of the rating of personal protective equipment.

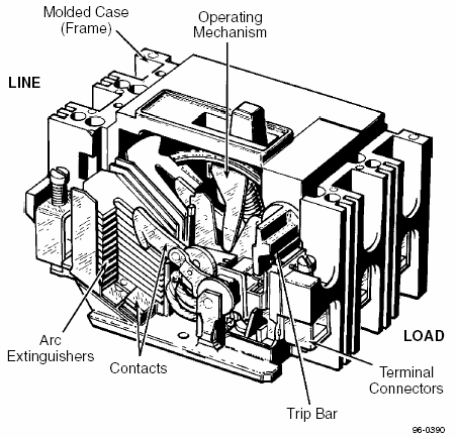


Fig. 1: Principle Components

Another consideration is addressed by OSHA in 29 CFR 1910.334(b)(2) which states:

*"**Reclosing circuits after protective device operation**. After a circuit is deenergized by a circuit protective device, the circuit may NOT be manually reenergized until it has been determined that the equipment and circuit can be safely reenergized. The repetitive manual reclosing of circuit breakers or reenergizing circuits through replaced fuses is prohibited.*

***NOTE:** When it can be determined from the design of the circuit and the overcurrent devices involved that the automatic operation of a device was caused by an overload rather than a fault condition, no examination of the circuit or connected equipment is needed before the circuit is reenergized."*

The safety of the employee manually operating the circuit breaker is at risk if the short circuit condition still exists when reclosing the breaker. OSHA no longer allows the past practice of resetting a circuit breaker one, two, or three times before investigating the cause of the trip. This previous practice has caused numerous burn injuries that resulted from the explosion of electrical equipment. **BEFORE** resetting a circuit breaker, it, along with the circuit and equipment, must be tested and inspected, by a qualified person, to ensure a short circuit condition does not exist and that it is safe to reset the breaker.

Any time a circuit breaker has operated and the reason is unknown, the breaker, circuit, and equipment must be inspected for a short circuit condition. Melted arc chutes will not interrupt fault currents. If the breaker cannot interrupt a second fault, it will fail and may destroy its enclosure and create a hazard for anyone working near the equipment.

To further emphasize this point the following quote is provided:

"After a high level fault has occurred in equipment that is properly rated and installed, it is not always clear to investigating electricians what damage has occurred inside encased equipment. The circuit breaker may well appear virtually clean while its internal condition is unknown. For such situations, the NEMA AB4 'Guidelines for Inspection and Preventive Maintenance of MCCBs Used in Commercial and Industrial Applications' may be of help. Circuit breakers unsuitable for continued service may be identified by simple inspection under these guidelines. Testing outlined in the document is another and more definite step that will help to identify circuit breakers that are not suitable for continued service.

After the occurrence of a short circuit, it is important that the cause be investigated and repaired and that the condition of the installed equipment be investigated. A circuit breaker may require replacement just as any other switching device, wiring or electrical equipment in the circuit that has been exposed to a short circuit. Questionable circuit breakers must be replaced for continued, dependable circuit protection." [10]

The condition of the circuit breaker must be known to ensure that it functions properly and safely before it is put it back into service.

2) Low-Voltage Power Circuit Breakers: Low-voltage power circuit breakers are manufactured under a high degree of quality control, of the best materials available, and with a high degree of tooling for operational accuracy. Manufacturer's tests, per UL 1066 *Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures*, show these circuit breakers to have durability beyond the minimum standards requirements. All of these factors give these circuit breakers a very high reliability rating when proper maintenance is performed per the manufacturer instrctions. However, because of the varying application conditions and the dependence placed upon them for protection of electrical systems and equipment as well as the assurance of service continuity, inspections and maintenance checks must be made on a regular basis. Several studies have shown that low-voltage power circuit breakers, which were not maintained within a 5-year period, have a 50% failure rate.

Maintenance of these breakers will generally consist of keeping them clean and properly lubricated. In addition, it is also necessary to periodically check the circuit breaker contacts for wear and alignment and inspect the circuit breaker arc chutes, especially after opening a fault condition. The frequency of maintenance will depend to some extent on the cleanliness and environmental conditions of the surrounding area. If there were very much dust, lint, moisture, or other foreign matter present then more frequent maintenance would be required.

Industry standards for, as well as manufacturers of, low-voltage power circuit breakers recommend a general inspection and lubrication after a specified number of operations or at least once per year, whichever comes first. Some manufacturers also recommend this same inspection and maintenance be performed after the first six months of service for a new circuit breaker, regardless of the number of operations. If the breaker remains open or closed for a long period of time, it is recommended that arrangements be made to open and close the breaker several times in succession. Environmental conditions would also play a major role in the scheduling of inspections and maintenance. If the initial inspection indicates that maintenance is not required at that time, the period may be extended to a more economical point. However, more frequent inspections and maintenance may be required if severe load conditions exist or if an inspection reveals heavy accumulations of dirt, moisture, or other foreign

matter that might cause mechanical, insulation, or electrical failure. Mechanical failure would include an unintentional time delay in the circuit breakers tripping operation due to dry, dirty, or corroded pivot points or by hardened or sticky lubricant in the moving parts of the operating mechanism. The manufacturer's instructions must be followed in order to minimize the risk of any unintentional time delay.

Figure 2 provides an illustration of the numerous points where lubrication would be required and where dirt, moisture, corrosion or other foreign matter could accumulate causing a time delay in, or complete failure of, the circuit breaker operation.

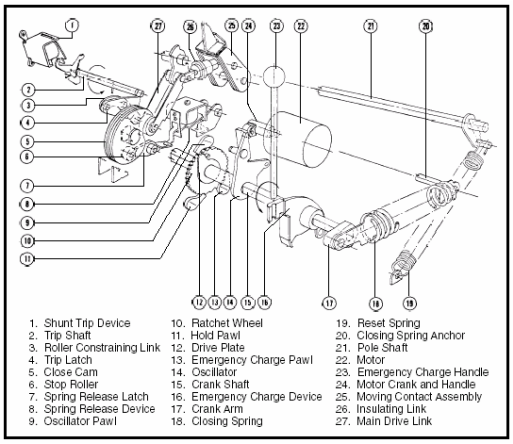


Fig. 2: Power-Operated Mechanism

III. ANALYSIS OF ELECTRICAL EQUIPMENT INSTALLATIONS AND MAINTENANCE PROGRAMS PRACTICED FOR LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES

In testing a variety of low-voltage power circuit breakers in a manufacturing facility there were several failures that occurred. Nine circuit breakers were removed from service in order to perform testing of their tripping capabilities. One breaker tripped according to the manufactures time-current curves for the trip device. Two of the breakers tripped before the test current reached the long-time trip setting value. The remaining six breakers would not trip, regardless of the amount of primary injection current applied to them. Further investigation revealed that these nine circuit breakers were last tested and maintained five to eight years previous. It should also be noted that the breaker mechanisms had been lubricated with a penatrant rather than a lubricant. Penatrants are not lubricants and they become extremely sticky in a very short period of time. A sticky operating mechanism will generally cause excessive time delays in the operation of the circuit breaker. In six of the nine breakers noted, the operating mechanism did not work due to improper lubrication. If these breakers were called upon to open a circuit under fault conditions they would fail, equipment would be damaged or destroyed, unnecessary downtime would occur, and employee's lives would be put in jeopardy.

In another industrial facility it was reported that it was not uncommon to have a time delay of several seconds or in some cases minutes from the time a trip button was pushed until the breaker finally opened.

IV. FAILURE STATISTICS FOR LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES

Several studies on electrical equipment failures have been completed over the years by IEEE. This studies have generated failure statisics on electrical distribution system equipment and components. IEEE Std. 493-1997 (Gold Book) " IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems" contains the information and statistics from these studies and can be used to provide faliure data of electirical equipment and components such as low voltage circuit breakers. The primary study that this paper will focus on was conducted in 1974. However, the results from a more recent study, completed in 1996, will also be given.

One key study that was completed and yields reliability data on circuit breakers was completed in 1974. These study results were based upon low and medium voltage power circuit breakers (drawout and fixed) and fixed mounted molded case circuit breakers. The results of the study indicated:

- 32% of all circuit breakers failed while in service.
- 9% of all circuit breakers failed while opening.
- 7% of all circuit breakers failed due to damage while successfully opening.
- 42% of all circuit breakers failed by opening when it should not have opened.
- 77% of fixed mounted circuit breakers (0-600V including molded case) failed while in service.
- 18% of all circuit breakers had a mechanical failure
- 28% of all circuit breakers had an electric-protective device failure.
- 23% of all circuit breakers failures were suspected to be caused by manufacturer defective component.
- 23% of all circuit breaker failures were suspected to be caused by inadequate maintenance.
- 73% of all circuit breaker failures required round-the-clock all-out efforts.

A 1996 IEEE survey was conducted on low voltage power circuit breakers and the results concluded:

- 19.4% of low voltage power circuit breakers with electromechanical trip units had unacceptable operation.
- 10.7% of low voltage power circuit breakers with solid-state trip units had unacceptable operation.

V. RELIABILITY AND INTEGRITY OF LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES

Reviewing the data from the IEEE studies, it can be seen that nearly 1/3 of all circuit breakers failed while in service and thus would not have been identified unless proper maintenance was performed. In addition, 16% of all circuit breakers failed or were damaged while opening. Thus, if proper maintenance was not completed these may have caused a serious safety issue, especially if the circuit breaker was attempted to be re-closed without performing needed maintenance.

The fact that 42% of all circuit breakers failed by opening when it should not have opened suggests improper circuit breaker settings or a lack of selective coordination. This type of circuit breaker failure can significantly affect plant processes and could result in a total plant shutdown.

Also of significance is that a very large percentage of fixed mounted circuit breakers, including molded case had a very high failure rate of 77%. This is most likely due to the fact that maintenance of this style of device is often overlooked, but certainly just as important.

The fact that 18% of all circuit breakers had a mechanical failure and 28% of all circuit breakers had a electric-protective device failure suggests that both the mechanical linkages as well as the trip units need to be maintained. Furthermore, although mechanical maintenance is important, proper testing of the trip unit is much more critical.

Also of importance to the user, is the realization that maintenance and testing is needed due to the fact that nearly ¼ of all circuit breaker failures were caused by a manufacturer defective component and nearly another ¼ of all circuit breaker failures were due to inadequate maintenance. Thus, if proper maintenance and testing is performed, potentially 50% of the failures could be eliminated or identified before a problem occurs. But perhaps the most important issue for an end user is downtime. With regard to this concern, the study indicated 73% of all circuit breaker failures required round-the-clock all-out efforts. This could most likely be greatly reduced if preventative maintenance was performed.

The results from the 1996 IEEE study show that technology has improved the failure rate of low voltage power circuit breakers and could potentially be cut by almost half, but maintenance and testing is still needed.

VI. ARC FLASH HAZARD CONSIDERATIONS

As mentioned previously, maintenance and testing is essential to ensure proper protection of equipment and personnel. In regards to personnel protection, NFPA 70E-2000, Part II, paragraph 2-1.3.3 requires a flash hazard analysis be performed before anyone approaches exposed electrical conductors or circuit parts that have not been placed in an electrically safe work condition. In addition, Paragraph 2-1.3.3.2 requires a flash protection boundary to be established. All calculations for determining the incident energy of an arc and for establishing a flash protection boundary require the arc clearing time. This clearing time is derived from the engineering coordination study, which is based on what the protective devices are supposed to do.

Maintenance is a very critical part of the flash hazard issue. The information provided in this paper clearly indicates the need for a preventive maintenance program on these circuit protective devices. Evidence has proven that inadequate maintenance can cause unintentional time delays in the clearing of a short circuit condition. If, for example, a low-voltage power circuit breaker had not been operated or maintained for several years and the lubrication had become sticky or hardened, the circuit breaker could take several additional cycles, seconds, minutes, or longer to clear a fault condition. The following is a specific example:

If a Flash Hazard Analysis is performed based on what the system is supposed to do, let's say a 5 cycle clearing time, and there is an unintentional time delay, due to a sticky mechanism, and the breaker clears in 30 cycles, the worker could be seriously injured or killed because he/she was under protected.

If the calculation is performed for a 20,000-amp fault, 480 volts, 3-inch arc gap, the worker is 18 inches from the arc, with a 5 cycle clearing time for a 3-phase arc in a box (enclosure), the results would be approximately 6.5 cal/cm^2 which would require an Arc/Flash Category 2 protection based on NFPA 70E-2000, Part II, Table 3-3.9.3.

The following example (Figure 3) uses the Heat Flux Calculator [14] and the values above for a 5 cycle clearing time:

```
**************************************************************
This program is made available to the general public for the
purpose of calculating heat flux received at a surface some
distance from an electric arc. The use of this program is the
responsibility of the user. The author makes no warranty to the
accuracy of the results and accepts no responsibility any dam-
age that may arise from its use.
**************************************************************

Enter the arc current(amps) ? 20000
Enter the arc gap(inches) ? 3
Enter the supply voltage(volts) ? 480
Arc column area  43.03264  sq. inches
Arc column cir. 14.34421  inches
Arc diameter  4.565908  inches
Arc power in watts -  1781250
Arc power in calories/sec -  425540.6
Heat flux on surface of arc  1533.146 cal/cm^2-sec
Enter the distance from the arc to the receiving surface ? 18
Transfer Shape Factor  1.482744E-02
Heat Flux at Receiving Surface  22.73263  cal/cm^2-sec
Enter the number of cycles for the arc duration ? 5
Arc Duration  8.333001E-02 seconds
Total Calories per Sq. Cm. at Receiving Surface  1.89431

 Do You Wish To Run Another Case? (Y or N) ?
```

Fig. 3: Calculation with a 5 Cycle Clearing Time

This value of 1.89431 cal/cm^2 is based on a single-phase arc in open-air. As a general rule of thumb, the value of 1.89431 would be multiplied by a factor of 2 for a single-phase arc in a box (2 x 1.89431 = 3.78862 cal/cm^2 – Category 1) and by a factor of 3.4 for a multi-phase arc in a box (3.4 x 1.89431 = 6.440654 cal/cm^2 – Category 2).

If the clearing time is increased to 30 cycles (Figure 4) then the results are approximately 38.7 cal/cm^2, which requires an Arc/Flash Category 4 protection.

```
****************************************************************
This program is made available to the general public for the
purpose of calculating heat flux received at a surface some
distance from an electric arc. The use of this program is the
responsibility of the user. The author makes no warranty to the
accuracy of the results and accepts no responsibility any dam-
age that may arise from its use.
****************************************************************

Enter the arc current(amps) ? 20000
Enter the arc gap(inches) ? 3
Enter the supply voltage(volts) ? 480
Arc column area  43.03264  sq. inches
Arc column cir. 14.34421  inches
Arc diameter  4.565908  inches
Arc power in watts -  1781250
Arc power in calories/sec -  425540.6
Heat flux on surface of arc  1533.146 cal/cm^2-sec
Enter the distance from the arc to the receiving surface ? 18
Transfer Shape Factor  1.482744E-02
Heat Flux at Receiving Surface  22.73263  cal/cm^2-sec
Enter the number of cycles for the arc duration ? 30
Arc Duration  .49998 seconds
Total Calories per Sq. Cm. at Receiving Surface  11.36586

 Do You Wish To Run Another Case? (Y or N) ?
```

Fig. 4: Calculation with a 30 Cycle Clearing Time

The value of 11.36586 cal/cm^2 is based on a single-phase arc in open-air. Again, as a general rule of thumb, the value of 11.36586 would be multiplied by a factor of 2 for a single-phase arc in a box (2 x 11.36586 = 22.73172 cal/cm^2 – Category 3) and by a factor of 3.4 for a multi-phase arc in a box (3.4 x 11.36586 = 38.643924 cal/cm^2 – Category 4).

Therefore, as can be seen, maintenance is extremely important to an electrical safety program. Maintenance must be performed according to the manufacturer's instructions in order to minimize the risk of having an unintentional time delay in the operation of the circuit protective devices.

VII. CONCLUSION

In order to protect electrical equipment and people, proper electrical equipment preventative maintenance must be performed. Several standards and guides exist to assist users with electrical equipment maintenance. Provided the overcurrent protective devices are properly maintained, checked and tested for proper calibration and operation, equipment damage and arc flash hazards can be limited as expected.

VIII. REFERNECES

[1] NFPA 70B, Recommended Practice for Electrical Equipment Maintenance, 2002 Edition
[2] IEEE Standard 902-1998 (Yellow Book), Guide For Maintenance, Operation, And Safety Of Industrial And Commercial Power Systems
[3] NEMA Standard AB 4, Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications
[4] IEEE Standard 493-1997 (Gold Book), Recommended Practice For The Design Of Reliable Industrial And Commercial Power Systems
[5] IEEE Standard 1015-1997 (Blue Book), Recommended Practice For Applying Low-Voltage Circuit Breakers Used In Industrial And Commercial Power Systems
[6] NFPA 70E-2000, Standard for Electrical Safety Requirements for Employee Workplaces, 2000 Edition
[7] NFPA 70, National Electrical Code
[8] IEEE Standard 1584-2002, Guide for Arc Flash Hazard Calculations
[9] NETA, Maintenance Testing Specifications for Electrical Power Distribution Equipment and Systems 2001 Edition
[10] National Equipment Manufacturer's Association (NEMA) Vince A. Baclawski, Technical Director, Power Distribution Products, NEMA; EC&M magazine, pp. 10, January 1995
[11] Manufacturer's Instruction Books
[12] IEC 60947-1, Low Voltage Switchgear and Controlgear - Part I: General Rules, 2001 Edition
[13] IEC 60947-2, Low Voltage Switchgear and Controlgear - Part 2: Circuit Breakers, 2003 Edition
[14] Heat Flux Calculator, a free shareware program developed by Alan Privette of Duke Power. (Available from several Internet sources)

IX. VITA

Mike Callanan Mike is the Senior Director of Safety, Codes & Standards for the National Joint Apprenticeship & Training Committee (NJATC) in Washington D.C. The NJATC is the training arm of the International Brotherhood of Electrical Workers (IBEW) and the National Electrical Contractors Association (NECA). Mike also serves as the Director of Codes & Standards for the IBEW. In this capacity he represents the IBEW on the Technical Correlating Committee (TCC) of NFPA 70, The National Electrical Code. He is a Principal Member of NFPA 70E, The Standard for Electrical Safety Requirements for Employee Workplaces and NFPA 70B, Electrical Equipment Maintenance. Mr. Callanan also serves as the Chairman of NFPA 79, Electrical Standard for Industrial Machinery. In addition to his Codes & Standards responsibilities, Mike is an OSHA Master Instructor and conducts OSHA training seminars on OSHA 1926 Construction and 1910 General Industry Standards.

Dennis K. Neitzel, CPE (M. IEEE) Dennis K. Neitzel, CPE, Director of AVO Engineering, Safety, and Training, Dallas, Texas, earned his Bachelor's degree in Electrical Engineering Management in 1986 and his Master's degree in Electrical Engineering Applied Sciences in 1991. Before coming to AVO in 1989, he was a Senior Project Engineer in electrical design at Westinghouse Idaho Nuclear Co., at the Idaho National Engineering and Environmental Laboratory. Mr. Neitzel started his career in the electrical field in 1967 while serving in the U.S. Air Force. He is a member of the Institute of Electrical and Electronics Engineers (IEEE), the American Society of Safety Engineers (ASSE), the Association for Facilities Engineering (AFE), the International Association of Electrical Inspectors (IAEI), and the National Fire Protection Association (NFPA). Mr. Neitzel earned his Certified Plant Engineer (CPE) in 1992 through the AFE and his Certified Electrical Inspector-General in 1995 through the IAEI. He has been a Principle Committee Member for the NFPA 70E, "Standard for Electrical Safety Requirements for Employee Workplaces" since 1992, and is co-author of the Electrical Safety Handbook, Second Edition, McGraw-Hill Publishers. He is also the Working Group Chairman for the revision of IEEE Std 902, "Guide for Maintenance, Operation, and Safety of Industrial and Commercial Power Systems". Mr. Neitzel has published numerous magazine articles on electrical safety and

technician training programs and serves as the ASSE Engineering Practice Specialty's ByDesign Newsletter Editor.

Dan Neeser (M. IEEE) Dan Neeser is employed by Cooper Bussmann and holds the title of Marketing Manager, Construction/Contractor. He participates in IEEE, NEMA, NFPA, NJATC, IBEW, NECA, and IAEI activities. He specializes in training on the design and application of overcurrent protective devices in electrical distribution systems in accordance with the National Electrical Code. Prior to his position with Cooper Bussmann, he was a Sales Engineer for Cutler-Hammer focusing on construction project sales of electrical distribution products. He has a BSME from the University of North Dakota.

Series Rated Systems

Under most circumstances, selection of a series rated system will reduce initial cost and size, since downstream breakers are not fully-rated for the prospective short-circuit fault current at their point of application. The interrupting rating of the upstream breaker must always be equal to or greater than the available fault current at its line terminals. In addition, downstream breakers must have been tested in combination with the upstream breaker and shown to be protected by the upstream breaker at the assigned series rated interrupting rating. The net result is that the system can be assigned a "series rated" or "integrated" rating higher than the rating of the downstream breaker when it is tested or applied alone. Design of the system and selection of breakers is based on short-circuit interruption test specified and witnessed by UL.

Because of their blow-open design, most molded case circuit breakers are current limiting to some degree. In a series rated application and in the event of a major fault, both upstream and downstream breakers open, protecting the lower-rated downstream devices by limiting the let-through current.

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To develop a series rated protective system, it is suggested that the design engineer, after completing preliminary steps:

- Define available fault current at the line side terminals of the upstream breaker.
- Select an upstream breaker with an interrupting rating equal to or greater than the available fault current.
- Verify the series tested interrupting ratings of the selected combination of breakers by referring to the tables in the back of this brochure.
- Confirm, during installation, that the correct breakers have been selected by checking the nameplates appearing on the end-use equipment.

Evaluating the Protection Systems
Designed properly, all three systems protect electrical equipment with equal effectiveness. But initial cost and continuity of service can vary widely depending on the inherent characteristics of the system, and on the design philosophy adopted.

Fully-rated System
A fully-rated system is typically less costly than a selectively-coordinated system and more costly than a series rated system. All breakers are rated for full fault current at their point of application in accordance with the National Electrical Code. The continuity of service provided by the system is less than with a selectively-coordinated system, and can be more than a series rated system.

Selectively-coordinated System
A selectively-coordinated system is most costly of the three. All breakers are fully-rated and upstream breakers must have adequate short-time delay adjusting capabilities. Continuity of service is the highest possible.

Series Rated System
A series rated system is least costly. The upstream breaker is always fully-rated, but the interrupting ratings of downstream breakers are normally lower. Service continuity can be acceptable after initial start-up, since the lower-level arcing faults most likely to occur after that time can be cleared by the downstream breaker alone. However, under high fault conditions, both the upstream and downstream breakers would open, eliminating service to the affected portion of the system.

National Electrical Code Requirements
Requirements of the National Electrical Code for short-circuit ratings may now be met by equipment that is marked with ratings adequate for the available fault current at their point of application in the electrical system. Refer to the current NEC for specific requirements.

General Discussion
Available Short-circuit Current. Service equipment shall be suitable for the short-circuit current available at its supply terminal.

Approval. The conductors and equipment required or permitted by the Code shall be acceptable only if approved. See Examination of Equipment for Safety and Examination, Identification, Installation, and Use of Equipment. See definitions of "Approved", "Identified", "Labeled" and "Listed".

Examination, Identification, Installation and Use of Equipment

A. Examination: In judging equipment, considerations such as the following should be evaluated.

1. Suitability for installation and use in conformity with the provisions of this Code. Suitability of equipment use may be identified by a description marked on or provided with a product to identify the suitability of the product for a specific purpose, environment, or application. Suitability of equipment may be evidence by listing or labeling.
2. Mechanical strength and durability, including, for parts designed to enclose and protect other equipment, the adequacy of the protection thus provided.
3. Wire-ending and connection space.
4. Electrical insulation.
5. Heating effects under normal conditions of use and also under abnormal conditions likely to arise in service.
6. Arcing effects.
7. Classification by type, size, voltage, current capacity and specific use.
8. Other factors which contribute to the practical safeguarding of persons using or likely to come in contact with the equipment.

B. Installation and Use: Listed or labeled equipment shall be used or installed in accordance with any instructions included in the listing or labeling.

Interrupting Rating. Equipment intended to break current at fault levels shall have an interrupting rating sufficient for the system voltage and the current which is available at the terminals of the equipment. Equipment intended to break current at other than fault levels shall have an interrupting rating at system voltage sufficient for the current that must be interrupted.

Circuit Impedance and Other Characteristics
The overcurrent protective devices, the total impedance, the component short-circuit withstanding ratings, and other characteristics of the circuit to be protected shall be so selected and coordinated as to permit the circuit protective devices used to clear a fault without the occurrence of extensive damage to the electrical components of the circuit. This fault shall be assumed to be either two or more of the circuit conductors, or between any circuit conductor and the grounding conductor or enclosing metal raceway.

Design/Test Considerations for Series Coordinated Circuit Breakers
Test Procedures for all Cutler-Hammer Series C and other molded case circuit breakers intended for application in series connected systems are in full compliance with all applicable paragraphs of the latest edition of UL 489①. The entire system is tested, since such tests are the only way to correctly verify the performance of overcurrent devices under short-circuit conditions.

Calibration, interruption, trip-out, and dielectric withstand tests are performed. Breakers in their as-received condition are used for the interrupting and intermediate interrupting capability tests. If agreeable to concerned parties, previously tested samples may be used. The interrupting rating of the line-side circuit breaker is equal to or greater than the maximum available fault current on the distribution system at its point of intended application.

Tests comply also with the intent of the proposed revisions to applicable IEC documents.①

Tests are completed in a well-defined sequence:

- Interrupting Tests
- Intermediate Interrupting Tests
- Trip-out Tests
- Dielectric Voltage-withstand Tests

Cutler-Hammer Series C Circuit Breakers intended for application in series rated systems are subjected, in the following sequence, to interrupting ability, intermediate interrupting ability, trip-out, and dielectric voltage-withstand tests.

① For further information, see IEEE Standards 141, 242 and 446.

During testing of the series rated circuit breakers, each breaker is mounted in the smallest enclosure in which it is to be used; openings in the enclosure do not exceed ten percent of its total external area, and there are no openings directly opposite a vent in a circuit breaker case. The two enclosures are connected by a 12-inch (305mm) conduit of any diameter. Each lead from test terminals to the line-side breaker is less than four feet (1.2m) per breaker(s), and each load shorting the load-side breaker(s) is sized based on the rating of the load-side breaker. The combined length of the lead from the line-side overcurrent protective device of the load-side breaker and from the load-side breaker to the shorting point, is less than four feet (1.2) per pole.

Exception: the breakers may be mounted in the end-use equipment that will contain them and is marked for use with the series combination. The load-side breaker is positioned as close as possible to the line-side breaker(s). Line and load leads are less than 4 feet (1.2m).

A fuse is connected between the enclosure and line terminal of the pole least likely to arc to the enclosure ,or the neutral, if the breaker is rated 120/240 or 480Y277 Vac. The connection to the load-side of the limiting impedance is #10 AWG copper wire less than 6 feet (1.8m) long. The fuse is a 30A non-renewable type acceptable for branch circuit protection; its voltage rating is not less than the rating of the device, and its interrupting rating is not less than the available current.

1. *Interrupting tests:*

a. The test circuit is closed on the series combination with all breakers fully closed; and
b. The load-side breaker is closed on the circuit while the line-side breaker is fully closed.

Note: Random closing is used in all three-phase tests. When the circuit is closed on the combination, closing is controlled in single-phase tests so that closing occurs within ten electrical degrees of the zero-point of the supply voltage wave.

2. *Intermediate interrupting tests* at the specified available current and maximum voltage. Procedures are identical to those described in 1a and 1b (above) but at the maximum current level that causes the load-side breaker to open, but not the line-side breaker. If the line-side breaker is current-limiting, the series combination shall be evaluated in the region below its current-limiting threshold. (There is no need for these tests if the current is less than the interrupting rating on the load-side breaker).
3. *Trip-out tests* of the load-side breaker at 250 percent of the marked ampere rating.
4. *Dielectric voltage-withstand tests* verify that the breaker can withstand, without breakdown, a 60 (48-62) Hz essentially sinusoidal potential for one minute.

Circuit Breaker Identification
Marking of all Series C and other Cutler-Hammer circuit breakers is clear for easy identification of type, rating and operating status. Nameplates are color-coded for immediate identification of rating, and a color-coded bar identifies the type and interrupting rating at common application voltages. Operating status is indicated clearly by the position of the handle and color-coded flags. On and off positions are identified by English words and international symbols.

Scientists and engineers at the Cutler-Hammer Testing Laboratory assure that Cutler-Hammer Series C Circuit Breakers are the most reliable and develop new concepts and improvements in breaker design. Designs and reliability are verified, products are improved continuously and qualified to meet UL, NEMA, and other standards. In addition, engineers from any breaker or panelboard manufacturer can work along-side their peers from Cutler-Hammer to test their products in the lab.

The consolidated nameplate on all Series C Breakers provides complete identification and rating information in a format that is easy to read and understand.

The interrupting rating of the series combination is never permitted to be marked on the downstream breaker. However, the series rating may be marked on panelboards in which the combination has been tested and listed if:

- The upstream breaker is installed in the panelboard as a main breaker.
- The panelboard is a main-lug-only type and is specifically marked to indicate the type and rating of the upstream listed series tested breaker that must be applied with the panelboard.

Marking of Panelboards
Marking of panelboards conforms to the latest edition of UL 67. Markings are clear and understandable, and include the short-circuit rating in rms amperes; maximum voltage rating for each short-circuit rating; a statement indicating that additional or replacement devices shall be of the same type and of equal or greater interrupting capacity; and, when applicable, the identity of combinations of integral and branch-circuit overcurrent devices that are required when applying the marked short-circuit current rating.

Fuses
Fuses can be used instead of circuit breakers in fully-rated, selectively-coordinated and series connected protection systems. See the tables in the back of this brochure for fuse breakout data applied to series connected designs.

Don't apply fuses using the up-over-down method, which has been recommended by some fuse manufacturers for sizing a current-limiting fuse that protects a downstream molded case circuit breaker with a specified rms symmetrical interrupting rating. The method can lead to erroneous and unsafe conclusions, and should not be used.

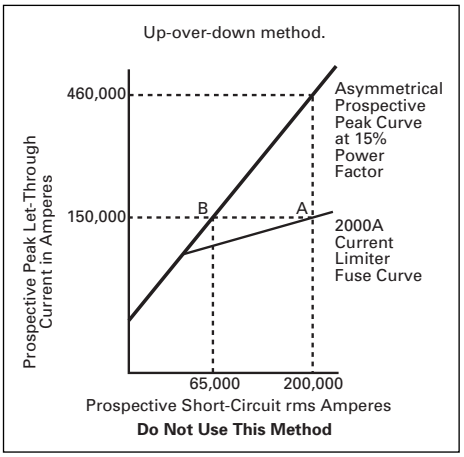
Example: Assume a specific type of current-limiting fuse rated 2000A. Then using the figure below:

1. Draw a vertical line from the prospective short-circuit current of 200kA to intersect the "typical peak let-through curve at "A."
2. Draw a horizontal line left from Point "A" to intersect the "prospective peak" curve at "B."
3. Drop a vertical line from "B" to intersect the horizontal axis and read the recommended rating, 65 kA rms, concluding that a circuit breaker with a 65 kA interrupting capacity will be protected by a specified 2000A current-limiting fuse.

This conclusion is wrong when the downstream service has a blow-open contact assembly, as does a molded case circuit breaker or similar device. It may be valid when the current-limiting fuse is sized to protect a passive bus bar system.

The reason: The up-over-down method ignores dynamic impedance (the inherent current-limiting of the downstream molded case circuit breaker). Such impedance is developed directly by the forces of the let-through current created when the contacts are blown open.

For proper application of current-limiting fuses, always refer to recommendations by the manufacturer of the circuit breaker, which are based on actual test data.



Application and Replacement of Breakers
Apply and replace breakers prudently, within the design and operating parameters of the power system. Use the following tables to select the size and type of Series C Circuit Breaker needed to fit virtually any application in series rated and other protective systems. Series C Breakers are highly-compatible across ratings, capacities and characteristic; prudent replacements are as important as initial selection.

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Index for Series Rating Tables

Circuit Breaker/Circuit Breaker Series Combinations①② 600 Volt System

Upstream Breaker	**Type**		**FD, FDB, HFD**	**FD, FDB, HFD**	**LCL**	**LCL**	**KDC**	**KDC**	**HLD, HLDB**	**HKD**	**JDC**
	Amperes, Maximum		150	70	400	250	400	400	600	400	250
	Limiter Type		LFD3150R	LFD3070R	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
System kA			200	200	100	100	50	42	35	35	35
System Volts			600	600	600	600	600	600	600	600	600
Downstream Breaker	**Range Amps**	**Poles**									
FDB	15-70	2, 3		■	■	■		■		■	■
FD	15-70	2, 3		■	■	■		■		■	■
HFD	15-70	2, 3		■	■	■		■		■	■
FDC	15-70	2, 3		■	■	■					
FDB	80-150	2, 3	■		■	■		■		■	■
FD	80-150	2, 3	■		■	■		■		■	■
HFD	80-150	2, 3	■		■	■		■		■	■
FDC	80-150	2, 3	■		■	■					
JD	70-250	2, 3			■	■	■			■	■
JDB	70-250	2, 3			■	■	■			■	■
HJD	70-250	2, 3			■	■	■			■	■
JDC	70-250	2, 3			■						
KD	100-400	2, 3			■		■		■		
KDB	100-400	2, 3			■		■		■		
HKD	100-400	2, 3			■		■				
KDC	100-400	2, 3			■						
LD, LDB	300-600	2, 3							■		
LC, LCG,LCA, LCGA	75-400	2, 3			■		■			■	
HLC, HLCG, HLCA, HLCGA	75-400	2, 3			■		■			■	

The series combinations shown are UL recognized component rating only. Consult the equipment manufacturer for applicable UL recognized assembly combinations.

① Circuit Breaker/Circuit Breaker series rated combinations shown in above tabulations by Underwriters Laboratories, Inc. in their *Component Directory* (Yellow Book) under "Circuit Breakers — Series Connected."

② Only active Circuit Breaker types are included in the above tabulations. For additional information on inactive styles, consult the UL Yellow Book or contact Cutler-Hammer.

■ A solid block in the row of a particular downstream breaker indicates that the upstream device associated with the column provides a Series Rating for the parameter values of the column heading. If the solid block is accompanied by numbers in parentheses, then only the breaker ampacities listed in the parentheses have the Series Rating.

Series Connected Ratings: Series C and Other Cutler-Hammer Circuit Breakers

A wide range of breakers and combinations in the Cutler-Hammer Series C and other lines is available that has been tested in accordance with UL procedures for series connected ratings: individually enclosed breakers in series with main lug panelboards, main breakers integral with branch breakers in panelboards, in switchboards, and in meter centers. You can rely on the enclosed data for applications with other undefined distribution equipment where series application ratings can be an advantage.

Circuit Breaker/Circuit Breaker Series Combinations①② 600 Volt System

FDC	FDC	HLD, HLDB	KD, KDB	HJD	HFD	HFD	JD, JDB	FD	FD	Type
225	150	600	400	250	225	150	250	225	150	**Amperes, Maximum**
. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	**Limiter Type**
35	35	25	25	25	25	25	18	18	18	**System kA**
600	600	600	600	600	600	600	600	600	600	**System Volts**
■	■		■	■	■	■	■	■	■	FDB
■	■	■	■	■	■	■	■	■		FD
	■									HFD
										FDC
■	■		■	■	■	■	■	■	■	FDB
■	■	■	■	■	■	■		■		FD
	■									HFD
										FDC
		■	■	■						JD
		■	■	■						JDB
										HJD
										JDC
										KD
										KDB
										HKD
										KDC
										LD, LDB
			■							LC, LCG, LCA, LCGA
										HLC, HLCG, HLCA, HLCGA

① Circuit Breaker/Circuit Breaker series rated combinations shown in above tabulations by Underwriters Laboratories, Inc. in their *Component Directory* (Yellow Book) under "Circuit Breakers — Series Connected."

② Only active Circuit Breaker types are included in the above tabulations. For additional information on inactive styles, consult the UL Yellow Book or contact Cutler-Hammer.

■ A solid block in the row of a particular downstream breaker indicates that the upstream device associated with the column provides a Series Rating for the parameter values of the column heading. If the solid block is accompanied by numbers in parentheses, then only the breaker ampacities listed in the parentheses have the Series Rating.

Circuit Breaker/Circuit Breaker Series Combinations①② 480 Volt System

Upstream Breaker	Type		FDB, FD, HFD	FDB, FD, HFD	LCL	LCL	FCL	NB TRI-PAC	NB TRI-PAC	KDC	JDC	LA TRI-PAC
	Amperes, Maximum		150	70	400	250	100	800	500	400	250	400
	Limiter Type		LFD3150R	LFD3070R	. . . .	. . . .	. . . .	P20	P12	. . . .	. . . .	P10
System kA			200	200	150	150	150	100	100	100	100	100
System Volts			480	480	480	480	480	480	480	480	480	480
Downstream Breaker	Range Amperes	Poles										
EHD	15-100	2, 3	■ (80-100)	■ (15-70)	■	■	■			■	■	
FDB	15-150	2, 3	■ (80-150)	■ (15-70)	■	■	■ (15-100)			■	■	
FD	15-150	2, 3	■ (80-150)	■ (15-70)	■	■	■ (15-100)			■	■	
HFD	15-150	2, 3	■ (80-150)	■ (15-70)	■	■	■ (15-100)			■	■	
FDC	15-150	2, 3	■ (80-150)	■ (15-70)	■	■						
JD, JDB	70-250	2, 3			■	■			■	■	■	■
HJD	70-250	2, 3			■	■			■	■	■	■
KD, KDB	100-400	2, 3			■				■	■		■
HKD	100-400	2, 3			■				■	■		■
LD, LDB	300-600	2, 3										
LC, LCG, LCA, LCGA	75-600	2, 3			■ (75-400)			■	■ (75-500)	■ (75-400)		
HLC, HLCG, HLCA, HLCGA	75-600	2, 3			■ (75-400)					■ (75-400)		
LA, LAB, HLA	125-600	2, 3						■	■ (125-500)			
MA	125-800	2, 3						■	■ (125-500)			
MC, MCA, MCG, MCGA	400-800	2, 3						■	■ (400-500)			
NB	700-800	2, 3						■			■	

The series combinations shown are UL recognized component rating only. Consult the equipment manufacturer for applicable UL recognized assembly combinations.

① Circuit Breaker/Circuit Breaker series rated combinations shown in above tabulations by Underwriters Laboratories, Inc. in their *Component Directory* (Yellow Book) under "Circuit Breakers — Series Connected."

② Only active Circuit Breaker types are included in the above tabulations. For additional information on inactive styles, consult the UL Yellow Book or contact Cutler-Hammer.

■ A solid block in the row of a particular downstream breaker indicates that the upstream device associated with the column provides a Series Rating for the parameter values of the column heading. If the solid block is accompanied by numbers in parentheses, then only the breaker ampacities listed in the parentheses have the Series Rating.

Circuit Breaker/Circuit Breaker Series Combinations①② 480 Volt System

LA TRI-PAC	FDC	FDC	FB TRI-PAC	HLD, HLDB	HKD	HJD	HFD	HFD	KD, KDB	JD, JDB	FD	FD	Type
200	225	150	100	600	400	250	225	150	400	250	225	150	**Amperes, Maximum**
P08	. . . .	. . . .	P06	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	**Limiter Type**
100	100	100	100	65	65	65	65	65	35	25	25	25	**System kA**
480	480	480	480	480	480	480	480	480	480	480	480	480	**System Volts**
■	■	■	■		■	■	■	■	■	■	■	■	EHD
■ (15-100)	■	■	■ (15-100)		■	■	■	■	■	■	■	■	FDB
■ (15-100)		■	■ (15-100)		■	■		■	■				FD
■ (15-100)		■	■ (15-100)										HFD
													FDC
■ (70-200)					■	■							JD, JDB
■ (70-200)													HJD
					■								KD, KDB
													HKD
				■									LD, LDB
					■ (75-400)				■ (75-400)				LC, LCG, LCA, LCGA
													HLC, HLCG, HLCA, HLCGA
					■ (125-400)								LA, LAB, HLA
													MA
													MC, MCA, MCG, MCGA
													NB

① Circuit Breaker/Circuit Breaker series rated combinations shown in above tabulations by Underwriters Laboratories, Inc. in their *Component Directory* (Yellow Book) under "Circuit Breakers — Series Connected."

② Only active Circuit Breaker types are included in the above tabulations. For additional information on inactive styles, consult the UL Yellow Book or contact Cutler-Hammer.

■ A solid block in the row of a particular downstream breaker indicates that the upstream device associated with the column provides a Series Rating for the parameter values of the column heading. If the solid block is accompanied by numbers in parentheses, then only the breaker ampacities listed in the parentheses have the Series Rating.

Circuit Breaker/Circuit Breaker Series Combinations①② 480Y/277 Volt System

Upstream Breaker	Type		FD, FDB, HFD	FD, FDB, HFD	LCL	LCL	FCL	KDC	JDC	FDC	FDC	LA TRI-PAC
	Amperes, Maximum		150	70	400	250	100	400	250	225	150	200
	Limiter Type		LFD3150R	LFD3070R	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	P08
System kA			200	200	150	150	150	100	100	100	100	100
System Volts			480Y/277	480Y/277	480Y/277	480Y/277	480Y/277	480Y/277	480Y/277	480Y/277	480Y/277	480Y/277
Down-stream Breaker	Range Amps	Poles										
EHD	15-100	1			■	■	■	■	■		■	■
EHD	15-100	2, 3	■ (80-100)	■ (15-70)	■	■	■	■	■		■	■
FDB	15-150	2, 3	■ (80-150)	■ (15-70)	■	■	■	■	■		■	■ (15-100)
FD	15-150	1			■	■	■	■	■		■	■ (15-100)
FD	15-150	2, 3	■ (80-150)	■ (15-70)	■	■	■	■	■		■	■ (15-100)
HFD	15-150	1			■	■	■	■	■		■	■ (15-100)
HFD	15-150	2, 3	■ (80-150)	■ (15-70)	■	■	■	■	■		■	■ (15-100)
GHB, GHC	15-100	1			■	■	■	■	■	■	■	
GHB, GHC	15-100	2, 3	■ (80-100)	■ (15-70)	■	■	■	■ (15-50)	■ (15-50)	■	■	

The series combinations shown are UL recognized component rating only. Consult the equipment manufacturer for applicable UL recognized assembly combinations.

① Circuit Breaker/Circuit Breaker series rated combinations shown in above tabulations by Underwriters Laboratories, Inc. in their *Component Directory* (Yellow Book) under "Circuit Breakers — Series Connected."

② Only active Circuit Breaker types are included in the above tabulations. For additional information on inactive styles, consult the UL Yellow Book or contact Cutler-Hammer.

■ A solid block in the row of a particular down-stream breaker indicates that the upstream device associated with the column provides a Series Rating for the parameter values of the column heading. If the solid block is accompanied by numbers in parentheses, then only the breaker ampacities listed in the parentheses have the Series Rating.

Circuit Breaker/Circuit Breaker Series Combinations①② 480Y/277 Volt System

FB TRI-PAC	HKD	HJD	HFD	HFD	KD, KDB	KDC	HKD	JDC	HJD	JD, JDB	FD	FD	KD, KDB	JD, JDB	Type
100	400	250	225	150	400	400	400	250	250	250	225	150	400	250	**Amperes, Maximum**
P06	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	**Limiter Type**
100	65	65	65	65	35	25	25	25	25	25	25	25	22	22	**System kA**
480Y/ 277	480Y/ 277	480Y/ 277	480Y/ 277	480Y/ 277	480Y/ 277	480Y/ 277	480Y/ 277	480Y/ 277	480Y/ 277	480Y/ 277	480Y/ 277	480Y/ 277	480Y/ 277	480Y/ 277	**System Volts**
■	■	■		■	■	■	■	■	■	■		■	■	■	EHD
■	■	■		■	■	■	■	■	■	■		■	■	■	EHD
■ (15-100)	■	■		■	■	■	■	■	■			■	■		FDB
■ (15-100)	■	■		■	■	■	■	■	■				■		FD
■ (15-100)	■	■		■	■	■	■	■	■				■		FD
■ (15-100)						■									HFD
■ (15-100)						■									HFD
	■	■	■	■	■	■	■	■	■	■	■	■	■	■	GHB, GHC
	■ (15-50)	■ (15-50)	■	■	■ (15-50)	■	■	■	■	■ (15-50)	■	■	■	■	GHB, GHC

G

① Circuit Breaker/Circuit Breaker series rated combinations shown in above tabulations by Underwriters Laboratories, Inc. in their *Component Directory* (Yellow Book) under "Circuit Breakers — Series Connected."

② Only active Circuit Breaker types are included in the above tabulations. For additional information on inactive styles, consult the UL Yellow Book or contact Cutler-Hammer.

■ A solid block in the row of a particular downstream breaker indicates that the upstream device associated with the column provides a Series Rating for the parameter values of the column heading. If the solid block is accompanied by numbers in parentheses, then only the breaker ampacities listed in the parentheses have the Series Rating.

Circuit Breaker/Circuit Breaker Series Combinations①② 240 Volt System

Upstream Breaker	Type		LCL	KDC	LCL	JDC	FDC	FCL	FD, FDB, HFD	FD, FDB, HFD	HLD, HLDB	NB TRI-PAC	NB TRI-PAC	LA TRI-PAC	FB TRI-PAC	KDC	HKD	JDC	HJD	EDH
	Amperes, Maximum		400	400	250	250	150	100	150	70	600	800	500	200	100	400	400	250	250	225
	Limiter Type		....	....	....	....	....	....	LFD 3150 R	LFD 3070 R	....	P20	P12	P08	P06	....	....	....	....	....
System kA			200	200	200	200	200	200	200	200	100	100	100	100	100	100	100	100	100	100
System Volts			240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240
Downstream Breaker	Range Amperes	Poles																		
BA, BR, HQP, QC	15-100	2, 3	■		■			■	■ (80-100)	■ (15-70)				■	■			■		■
QBHW, BRH, QPHW, QCHW	15-100	2, 3	■		■			■	■ (80-100)	■ (15-70)				■	■	■	■	■		
HBAX, QHPX, QHCX	15-100	3	■		■			■	■ (80-100)	■ (15-70)				■	■	■		■		
HBAW, QH-PW, QHCW	15-20	3	■		■			■		■				■	■	■				
GB, GHB	15-100	2, 3	■	■	■	■	■	■	■ (80-100)	■ (15-70)	■					■	■	■	■	
GC, GHC	15-100	2, 3	■	■	■	■	■	■	■ (80-100)	■ (15-70)	■					■	■	■	■	
CA, CAH, HCA	100-225	2, 3	■	■	■	■								■		■	■	■	■	
BJ, BJH	100-225	2, 3	■	■	■	■											■		■	
ED	100-225	2, 3	■	■		■			■	■	■						■		■	
EDH	100-225	2, 3	■	■	■	■														
EHD	15-100	2, 3	■	■	■	■	■	■	■ (80-100)	■ (15-70)				■	■	■	■	■	■	
FD, FDB	15-150	2, 3	■	■	■	■	■	■ (15-100)	■ (80-150)	■ (15-70)	■			■ (15-100)	■ (15-100)	■	■	■	■	
HFD	15-150	2, 3	■	■	■	■	■	■ (15-100)	■ (80-150)	■ (15-70)						■		■		
JD, JDB	70-250	2, 3	■	■	■	■					■		■	■		■	■	■	■	
HJD	70-250	2, 3	■	■	■	■										■		■		
DK	250-400	2, 3	■	■							■	■	■			■	■			
KD, KDB	100-400	2, 3	■	■							■	■	■			■	■			
HKD	100-400	2, 3	■	■												■				
LD, LDB	300-600	2, 3									■									
HLD	300-600	2, 3																		
LC, LCG, LCA, LCGA	75-400	2, 3	■	■												■	■			
HLC, HLCG, HLCA, HLCGA	75-400	2, 3	■	■												■	■			

The series combinations shown are UL recognized component rating only. Consult the equipment manufacturer for applicable UL recognized assembly combinations.

① Circuit Breaker/Circuit Breaker series rated combinations shown in above tabulations by Underwriters Laboratories, Inc. in their *Component Directory* (Yellow Book) under "Circuit Breakers — Series Connected."

② Only active Circuit Breaker types are included in the above tabulations. For additional information on inactive styles, consult the UL Yellow Book or contact Cutler-Hammer.

■ A solid block in the row of a particular downstream breaker indicates that the upstream device associated with the column provides a Series Rating for the parameter values of the column heading. If the solid block is accompanied by numbers in parentheses, then only the breaker ampacities listed in the parentheses have the Series Rating.

Circuit Breaker/Circuit Breaker Series Combinations①② 240 Volt System

FDC	HFD	KDC	HKD	KD, KDB, DK	HJD	JD, JDB	ED	HFD	FD	GB, GC	KD, KDB, DK	KD, KDB, DK	CAH	BJH	QBHW, QPHW QCHW, BRH	FDB	EHD	Type
150	150	400	400	400	250	250	225	150	150	100	400	400	225	225	100	150	100	**Amperes, Maximum**
. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	**Limiter Type**
100	100	65	65	65	65	65	65	65	65	65	42	22	22	22	22	18	18	**System kA**
240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	**System Volts**
■	■	■	■	■	■ (15-70)	■ (15-70)	■	■ (15-70)	■	■	■ (15-70)	■ (15-70)	■	■	■	■ (15-70)	■ (15-70)	BA, BR, HQP, QC
■	■	■	■	■	■	■	■	■	■	■	■							QBHW, BRH, QPHW, QCHW
■		■	■		■	■		■	■	■								HBAX, QHOX, QHCX
■		■																HBAW, QHPW, QHCW
■	■	■	■		■			■										GB, GHB
■	■	■	■		■			■										GC, GHC
	■	■	■	■	■	■		■	■									CA, CAH, HCA
	■			■		■			■									BJ, BJH
																		ED
																		EDH
■	■	■	■	■	■	■		■	■									EHD
■	■	■	■	■	■	■		■	■									FD, FDB
■		■																HFD
		■	■		■													JD, JDB
		■																HJD
		■																DK
		■																KD, KDB
		■																HKD
																		LD, LDB
																		HLD
		■																LC, LCG, LCA, LCGA
		■			■													HLC, HLCG, HLCA, HLCGA

① Circuit Breaker/Circuit Breaker series rated combinations shown in above tabulations by Underwriters Laboratories, Inc. in their *Component Directory* (Yellow Book) under "Circuit Breakers — Series Connected."

② Only active Circuit Breaker types are included in the above tabulations. For additional information on inactive styles, consult the UL Yellow Book or contact Cutler-Hammer.

■ A solid block in the row of a particular downstream breaker indicates that the upstream device associated with the column provides a Series Rating for the parameter values of the column heading. If the solid block is accompanied by numbers in parentheses, then only the breaker ampacities listed in the parentheses have the Series Rating.

Circuit Breaker/Circuit Breaker Series Combinations①② 120/240 Volt System

Up-stream Breaker	Type		LCL	KDC	LCL	JDC	FDC	FCL	FD, FDB, HFD	FD, FDB, HFD	KDC	HKD	JDC	HJD	EDH	FDC	HFD	FB TRI-PAC
	Amperes Maximum		400	400	250	250	225	100	150	70	400	400	250	250	225	150	225	100
	Limiter Type		. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	LFD3150R	LFD3070R	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	P06
System kA			200	200	200	200	200	200	200	200	100	100	100	100	100	100	100	100
System Volts			120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240
Down-stream Breaker③	Range Amperes	Poles																
BA, BR, HQP, QC	15-70	1	■		■		■	■		■			■		■	■	■	■
BA, BR, HQP, QC	15-125	2	■ (15-100)		■ (15-100)		■ (15-70)	■ (15-100)	■ (80-100)	■ (15-70)			■		■	■	■ (15-70)	■ (15-100)
QBHW, BRH, QPHW, QCHW	15-70	1	■		■		■	■		■	■		■			■	■	■
QBHW, BRH, QPHW, QCHW	15-125	2	■ (15-100)		■ (15-100)		■ (15-100)	■ (15-100)	■ (80-100)	■ (15-70)	■		■			■	■ (15-100)	■ (15-100)
HBAX, QHPX, QHCX	15-70	1	■		■		■	■		■	■		■			■	■	■
HBAX, QHPX, QHCX	15-100	2	■		■		■	■	■ (80-100)	■ (15-70)	■		■			■	■	■
QHPW, HBAW, QHCW	15-30	1, 2	■		■		■	■			■							
QBGF, QPGF, QHCB	15-30	1, 2	■		■		■	■		■					■ (15-40)		■ (15-40)	■
GB, GHB	15-100	1, 2	■	■	■	■	■	■	■ (80-100)	■ (15-70)	■	■	■	■		■	■	
GC, GHC	15-100	1, 2	■	■	■	■	■	■	■ (80-100)	■ (15-70)	■	■	■	■		■	■	
EHD	15-100	1, 2	■	■	■	■	■	■	■ (80-100)	■ (15-70)	■	■	■	■		■	■	■
FD	15-150	1, 2	■	■	■	■	■	■ (15-100)	■ (80-150)	■ (15-70)	■	■	■	■		■	■	■
HFD	15-150	1, 2	■	■	■	■	■	■ (15-100)	■ (80-150)	■ (15-70)	■	■	■			■		

The series combinations shown are UL recognized component rating only. Consult the equipment manufacturer for applicable UL recognized assembly combinations.

① Circuit Breaker/Circuit Breaker series rated combinations shown in above tabulations by Underwriters Laboratories, Inc. in their *Component Directory* (Yellow Book) under "Circuit Breakers — Series Connected."

② Only active Circuit Breaker types are included in the above tabulations. For additional information on inactive styles, consult the UL Yellow Book or contact Cutler-Hammer.

■ A solid block in the row of a particular down-stream breaker indicates that the upstream device associated with the column provides a Series Rating for the parameter values of the column heading. If the solid block is accompanied by numbers in parentheses, then only the breaker ampacities listed in the parentheses have the Series Rating.

Circuit Breaker/Circuit Breaker Series Combinations①② 120/240 Volt System

LA TRI-PAC	KDC	JDC	FDC	HK D	KD, KDB, DK	HJD	JD, JDB	ED	HFD	FD	GB, GC	KD, KDB, DK	KD, KDB, DK	CAH	QBHW, QPHW, QCHW	BWH	BJH	FDB	EHD	Type
100	400	250	150	400	400	250	250	225	150	225	100	400	400	225	100	225	225	150	100	**Amperes, Maximum**
P08	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	**Limiter Type**
100	65	65	65	65	65	65	65	65	65	65	65	42	22	22	22	25	22	18	18	**System kA**
120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	120/240	**System Volts**
■	■	■ (15-100)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	BA, BR, HQP, QC
■ (15-100)	■ (15-70)	■	■	■		■	■	■	■	■ (15-100)	■ (15-100)	■	■ (15-70)	■	■ (15-100)	■ (15-100)	■ (15-100)	■	■	BA, BR, HQP, QC
■		■	■	■		■	■	■	■	■	■	■	■							QBHW, BRH, QPHW, QCHW
■ (15-100)		■	■	■		■	■	■ (15-100)	■ (15-100)	■ (15-100)	■ (15-100)	■	■							QBHW, BRH, QPHW, QCHW
■		■	■	■		■	■		■	■	■									HBAX, QHPX, QHCX
■		■	■	■		■	■		■	■	■									HBAX, QHPX, QHCX
																				QHPW, HBAW, QHCW
		■ (15-20)	■ (15-20)					■ (15-20)		■ (15-40)	■		■	■	■		■			QBGF, QPGF, GFCB
		■	■	■		■			■	■										GB, GHB
		■	■	■		■			■	■										GC, GHC
■		■	■	■	■	■	■		■	■		■								EHD
■		■	■	■		■			■	■										FD
		■	■	■																HFD

① Circuit Breaker/Circuit Breaker series rated combinations shown in above tabulations by Underwriters Laboratories, Inc. in their *Component Directory* (Yellow Book) under "Circuit Breakers — Series Connected."

② Only active Circuit Breaker types are included in the above tabulations. For additional information on inactive styles, consult the UL Yellow Book or contact Cutler-Hammer.

■ A solid block in the row of a particular downstream breaker indicates that the upstream device associated with the column provides a Series Rating for the parameter values of the column heading. If the solid block is accompanied by numbers in parentheses, then only the breaker ampacities listed in the parentheses have the Series Rating.

Fuse/Circuit Breaker Series Combinations①② Active Circuit Breakers

Upstream Fuse③	Type		J, T	RK	J,T	J, T	RK	RK	J, T	J, T	RK	J, T	J, T	RK	J, T	J, T	RK	J, T	RK
	Amperes, Maximum		200	100	400	600	400	200	400	200	100	400	200	100	400	200	100	200	100
System kA			100	100	100	100	100	100	200	200	200	100	200	200	100	100	100	100	100
System Volts			600	600	600	600	600	600	600	120/240	120/240	120/240	240	240	240	480	480	277	277
Downstream Breaker	Range Amperes	Poles																	
FD, HFD, FDC, FDB	15-150	2, 3, 4	■	■															
JD, HJD, JDC, JDB	70-250	2, 3, 4			■			■											
KD, HKD, KDC, KDB	100-400	2, 3, 4			■	■	■		■										
BA, BR, HQP, QC, QBHW, BRH, QPHW, HBAX, QHPX, QHCX	15-70	1								■	■	■							
BA, BR, HQP, QC, QBHW, BRH, QPHW, QCHW, HBAX, QHPX, QHCX	15-100	2								■	■	■							
QHPW, HBAW, QHCW	15-30	1, 2								■	■	■							
BA, BR, HQP, QC, QBHW, BRH, QPHW, QCHW	15-100	2, 3											■	■	■				
HBAX, QHPX, QHCX	15-100	3											■	■	■				
HBAW, QHPW, QHCW	15-20	3											■	■	■				
EHD	15-100	2, 3, 4														■	■		
EHD	15-100	1																■	■
FD, HFD	15-150	1																■	■

Fuse/Circuit Breaker Series Combinations①② Active Circuit Breakers

Upstream Fuse③	Type		J, T	RK	J,T	RK	J, T	RK	J, T	J, T	J, T	J	L	RK	L
	Amperes, Maximum		400	200	200	200	400	200	400	600	200	100	800	600	2000
System kA			200	100	200	200	100	100	200	100	65	100	200	200	200
System Volts			480/277	480/277	240	240	240	240	240	240	277	277	480	600	480
Downstream Breaker	Range Amperes	Poles													
GHBS	15-20	1									■	■			
GHB, GHC	15-100	2, 3	■	■											
CA	125-225	2, 3					■	■							
CAH, HCA	125-225	2, 3			■	■	■	■	■	■					
MA, HMA, MC, MCAM MCG, MCGA, HMCA, HMCGA, HMCG, MDL, HMDL, ND, HND	125-800	2, 3											■	■	
PC, PCG, PCA, PCGA	1000-3000	2, 3													■

① Fuse/Circuit Breaker and Fuse/Motor Circuit Protector series connected combinations shown in above tabulations listed by Underwriters Laboratories, Inc. in their *Component Directory* (Yellow Book) under "Circuit Breakers — Series Connected."
② Only active Circuit Breaker types are included in the above tabulations. For additional information on inactive styles, consult the UL Yellow Book or contact Cutler-Hammer.
③ RK ratings shown are applicable for both RK1 and RK5 fuses. RK1 fuses in higher ampere ratings may also provide series protection.

The series combinations shown are UL recognized component rating only. Consult the equipment manufacturer for applicable UL recognized assembly combinations.

Fuse/Circuit Breaker Series Combinations①② Active Circuit Breakers

Upstream Fuse③	Type		J, T	RK	L	RK	J, T	RK	L	RK	J, T	RK	RK	RK	J, T	RK	J, T	RK
	Amperes, Maximum		600	400	1200	600	600	400	1200	600	400	100	200	200	400	100	400	100
System kA			200	200	100	100	200	200	100	100	200	200	100	100	100	200	200	200
System Volts			600	600	600	600	480	480	480	240	120/240	120/240	120/240	277	277	240	240	480/277
Downstream Breaker	Range Amperes	Poles																
LC, LCA, LCG, LCGA, HLC, HLCA, HLCG, HLCGA	125-600	2, 3	■	■	■	■												
LC, LCA, LCG, LCAG, HLC, HLCA, HLCG, HLCGA	74-400	2, 3					■	■	■	■								
GB, GC, GHB, GHC	15-100	1									■	■	■					
GHB, GHC	15-100	1												■	■			
GB, GC, GHB, GHC	15-100	2, 3														■	■	
GHB, GHC	15-100	2, 3																■
MA, HMA, MC, MCA, MCG, MCGA, HMCA, HMCGA, HMCG, MDL, HMDL, ND, HND	125-800	2, 3	■						■									
NB, NC, NCA, NCG, NCGA, HNB, HNC, HNCA, HNCG, HNCGA, MDL, HMDL, ND, HND	600-1200	2, 3							■									

① Fuse/Circuit Breaker and Fuse/Motor Circuit Protector series connected combinations shown in above tabulations listed by Underwriters Laboratories, Inc. in their *Component Directory* (Yellow Book) under "Circuit Breakers — Series Connected."

② Only active Circuit Breaker types are included in the above tabulations. For additional information on inactive styles, consult the UL Yellow Book or contact Cutler-Hammer.

③ RK ratings shown are applicable for both RK1 and RK5 fuses. RK1 fuses in higher ampere ratings may also provide series protection.

G

Typical Specifications

Molded Case Protective Devices

A. Protective devices shall be molded case circuit breakers with inverse time and instantaneous tripping characteristics and shall be Cutler-Hammer Series C or approved equal.

B. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be nonwelding silver alloy and arc extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.

C. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the drawings.

D. Circuit breakers 150-, 250- [400-] [600-] ampere frame and below shall be Cutler-Hammer Series C with thermal-magnetic trip units and inverse time-current characteristics.

G

For electronic type trip units insert trip units into paragraph E from section G3

E. Circuit breakers [400-] [600-] ampere through 1200-ampere frame shall be Cutler-Hammer Series C with microprocessor-based RMS sensing trip units.

For 1600-ampere through 2500-ampere breakers insert applicable trip unit specification into paragraph F from section G3.

F. Circuit breakers 1600-ampere through 2500-ampere frame shall be Cutler-Hammer Series C with microprocessor-based RMS sensing trip units.

G. Ground fault protection shall be provided where indicated.

H. Where indicated circuit breakers shall be UL listed for series application.

I. Where indicated circuit breakers shall be current limiting.

J. Where indicated provide UL listed circuit breakers for applications at 100% of their continuous ampere rating in their intended enclosure.

For a complete product specification in CSI format, see **Cutler-Hammer Product Specification Guide**, section 16475.

Cutler-Hammer Series Rating Chart

Switchboards: PRL-C / PRL-i **(See Notes on Page 3)**

Panelboards: PRL 5P, PRL 4, PRL 3A & Pow-R-Command Panelboards

Max System Voltage	Maximum SCCR	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
120/240	100kA	LPN-RK	200	GB, GHB	ALL	1,2
		JJN, LPJ	400	BA, BAB, HQP, QBHW, QPHW	ALL	1,2
	200kA	LPN-RK	100	BA, BAB, HQP, QBHW, QPHW, GB, GHB	ALL	1,2
		JJN, LPJ	200	BA, BAB, HQP, QBHW, QPHW	ALL	1,2
		JJN, LPJ	400	GB, GHB	ALL	1,2
240	100kA	LPN-RK	200	GHB	ALL	1,2,3
				GB, CA	ALL	2,3
		JJN, LPJ	400	BAB_H, QBHW_H, HQP_H, QPHW_H	ALL	2,3
		JJN	600	CA, CAH, HCA	ALL	2,3
		KRP-C	6000	EHD, FD	ALL	1,2,3
		KRP-C	6000	FDB, ED, JDB, JD, DK, KDB, KD	ALL	2,3
	200kA	LPN-RK	100	GHB	ALL	1,2,3
				BAB_H, QBHW_H, HQP_H, QPHW_H, CAH, HCA, GB	ALL	2,3
		LPN-RK	200	GB, GHB	ALL	2,3
		JJN, LPJ	200	BAB_H, HQP_H, QBHW_H, QPHW_H, CA, CAH, HCA	ALL	2,3
		JJN, LPJ	400	GHB	ALL	1,2,3
				GB	ALL	2,3
480/277	65kA	JJS, LPJ	200	GHBS	ALL	1,2
	100kA	JJS, LPJ	100	GHBS	ALL	1,2
		LPS-RK	200	GHB	ALL	1,2,3
		LPJ	600	EHD, FD, HFD, FDC	ALL	2,3
		JJS	600	GHB, EHD, FD, HFD, FDC, JD, HJD, JDC	ALL	2,3
	200kA	LPS-RK	100	GHB	ALL	1,2,3
		JJS, LPJ	400			
480	100kA	LPS-RK	100	EHD	ALL	2,3
		JJS, LPJ	200	EHD, FD, HFD,FDC	ALL	2,3
		KRP-C	1200	MC, HMC, NC, HNC	ALL	2,3
	200kA	KRP-C	800	MC, HMC	ALL	2,3
600	100kA	LPS-RK	100	FD, HFD	ALL	2,3
				FDC	ALL	2,3
			200	JD, HJD, JDC	ALL	2,3
			400	KD, HKD, KDC	ALL	2,3
			600	LC	ALL	2,3
		JJS, LPJ	200	FD, HFD	ALL	2,3
				FDC	ALL	2,3
			400	JD, HJD, JDC	ALL	2,3
		KRP-C	1200	LC	ALL	2,3
	200kA	LPS-RK	400	LC	ALL	2,3
		JJS, LPJ	600	KD, HKD, KDC, LC	ALL	2,3

Cutler-Hammer Series Rating Chart

Panelboards: PRL 1A, PRL 2A, PRL 1A-LX, PRL 2A-LX **(See Notes Below & Page 3)**

Max System Voltage	Maximum SCCR	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
120/240	100kA	LPN-RK	200	GB, GHB	ALL	1,2
		JJN, LPJ	400	BA, BAB, HQP, QBHW, QPHW	ALL	1,2
	200kA	LPN-RK	100	BA, BAB, HQP, QBHW, QPHW, GB, GHB	ALL	1,2
		JJN, LPJ	200	BA, BAB, HQP, QBHW, QPHW	ALL	1,2
		JJN, LPJ	400	GB, GHB	ALL	1,2
240	100kA	LPN-RK	200	GHB	ALL	1,2,3
				GB, CA	ALL	2,3
		JJN, LPJ	400	BAB_H, QBHW_H, HQP_H, QPHW_H	ALL	2,3
		JJN	600	CA, CAH, HCA	ALL	2,3
		KRP-C	6000	EHD, FD	ALL	1,2,3
		KRP-C	6000	FDB, ED, JDB, JD, DK, KDB, KD	ALL	2,3
	200kA	LPN-RK	100	GHB	ALL	1,2,3
				BAB_H, QBHW_H, HQP_H, QPHW_H, CAH, HCA, GB	ALL	2,3
		LPN-RK	200	GB, GHB	ALL	2,3
		JJN, LPJ	200	BAB_H, HQP_H, QBHW_H, QPHW_H, CA, CAH, HCA	ALL	2,3
		JJN, LPJ	400	GHB	ALL	1,2,3
				GB	ALL	2,3
480/277	65kA	JJS, LPJ	200	GHBS	ALL	1,2
	100kA	JJS, LPJ	100	GHBS	ALL	1,2
		LPS-RK	200	GHB	ALL	1,2,3
		LPJ	600	EHD, FD, HFD, FDC	ALL	2,3
		JJS	600	GHB, EHD, FD, HFD, FDC, JD, HJD, JDC	ALL	2,3
	200kA	LPS-RK	100	GHB	ALL	1,2,3
		JJS, LPJ	400			

Notes for above Table:

1) The HQP & QPHW are not listed for use in the PRL1A-LX Panel.
2) PRL1A & PRL1A-LX are for use at 240V maximum.
3) Branch breakers for maximum 120/240V systems include: BAB, HQP, QBHW & QPHW.
4) Branch breakers for maximum 240V systems include: BAB_H, HQP_H, QBHW_H & QPHW_H.
5) PRL2A & PRL2A-LX, branch breakers include: GHB, GHBS & GB.
6) PRL1A-LX & PRL2A-LX Main & Sub-feed breakers include: ED, FD, HFD, FDC.
7) PRL1A & PRL2A Main & Sub-feed breakers include: CA, CAH, HCA, ED, FD, HFD, FDC, JD, HJD, JDC, KD, HKD & KDC.

Cutler-Hammer Series Rating Chart

Triple Series Rating - Switchboards: PRL-C & PRL-i **(See Comments Below)**

Panelboard Types: PRL 5P, PRL 4, PRL 3A, PRL 2A, PRL 2A-LX, PRL 1A, PRL 1A-LX & Pow-R-Command Panels

Max System Voltage	Maximum SCCR	Line Side Fuse	Tenant Main Type	Branch Type		
				Circuit Breaker	Amps	Poles
120/240	100kA	KRP-C (Max Fuse Size - 6000A)	DK, KDB, KD	GB, GHB	ALL	1,2
			JD, JDB	GB, GHB	ALL	1,2
			FD	GB, GHB	ALL	1,2
			FD, FDB	HQP	15-70	1,2
				BA, BAB	ALL	1,2
			EHD	BA, BAB, HQP	ALL	1,2
240	100kA	KRP-C (Max Fuse Size - 6000A)	DK, KDB, KD	GHB	ALL	1,2,3
				GB, EHD	ALL	2,3
				CA, CAH, HCA	ALL	2,3
				FD, FDB	ALL	2,3
				JD, JDB	ALL	2,3
			JD, JDB	GHB	ALL	1,2,3
				GB	ALL	2,3
			FD	GHB	ALL	1,2,3
				GB	ALL	2,3
			FD, FDB	BAB_H, QBHW_H, HQP_H, QPHW_H	ALL	2,3
			EHD	BAB_H, HQP_H	ALL	2,3

NOTE (1): The data in these charts was compiled from information in Cutler-Hammer, Series Rating Information Manual, catalog reference number 1C96944H01 Rev. E, pages 18-24, and Cutler-Hammer Consulting Application Catalog 12th Edition, pages F1-11 - F1-12. Cooper Bussmann assumes no responsibility for the accuracy or reliability of the information. The information contained in the tables may change without notice due to equipment design modifications.

NOTE (2): The line-side fused switch may be in a separate enclosure or in the same enclosure as the load-side circuit breaker. A line-side fused switch may be integral or remote.

NOTE (3): Max fuse current rating denotes the largest amperage fuse that may be used for that series rated combination. A lower amperage fuse may be substituted for the listed fuse.

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Data Bulletin

Replaces 2700DB9901R5/02, dated 06/2002

Switchboard/Panelboard Short-Circuit Current Ratings

Retain for future use.

INTRODUCTION

This document addresses Underwriters Laboratories® (UL®) short-circuit current rating (SCCR) requirements for switchboards and panelboards, along with three methods of system protection. It also provides circuit breaker interrupting ratings, series ratings tables, a fuse cross-reference table, and typical application examples.

UL requires that all UL Listed switchboards and panelboards be marked with a maximum SCCR. Testing switchboards and panelboards at the maximum SCCR evaluates the structure, bus, and overcurrent protective device (OCPD) as an entire system. The 2002 National Electrical Code® (NEC®) equipment requirements for SCCR are defined in Sections 110.9 and 110.10. The criteria for determining SCCR are found in UL Standard 891 for switchboards and UL Standard 67 for panelboards.

Three systems of short-circuit current protection are available:

- Fully-rated system
- Fully-rated, selectively-coordinated system
- Series-connected system

NOTE: The information contained in the tables of this data bulletin is correct at the time of printing; ratings may change without notice due to equipment design modifications. Refer to the series-connected ratings marked on the end-use equipment.

Fully-Rated System

In a fully-rated system, the interrupting rating of all OCPDs must be greater than or equal to the available fault current at the line side terminals of each device.

Fully-Rated, Selectively-Coordinated System

This is a fully-rated system with an additional design characteristic: within the range of selectivity, the OCPD closest to the fault opens the circuit, while the upstream OCPD remains closed. This limits unnecessary interruption of service to unaffected portions of the system. A system coordination study must be performed to ensure selectivity.

Series-Connected System

A series-rated system consists of a combination of OCPDs connected in series. The line side (main) device must have an interrupting rating equal to or greater than the available fault current at the line side terminals of the device. The load side (branch) circuit breaker has a lower interrupting rating that has been tested in combination with the line side (main) device.

To comply with Sections 110.22 and 240.86 of the 2002 NEC, all applicable series combinations must be marked on the end-use equipment. The UL Recognized Component Directory (Yellow Book) must not be used as an application guide for series-connected ratings in end-use equipment.

Section 240.86(B) further defines the use of series ratings with respect to motor contribution. This section requires that a calculation of the motor contribution be made if the motor(s) are connected to the load side of the higher rated device and to the line side of the lower rated device. If the sum of the motor full load current(s) is found to be higher than one percent of the interrupting rating of the lower rated device, then the series rating for that device cannot be used.

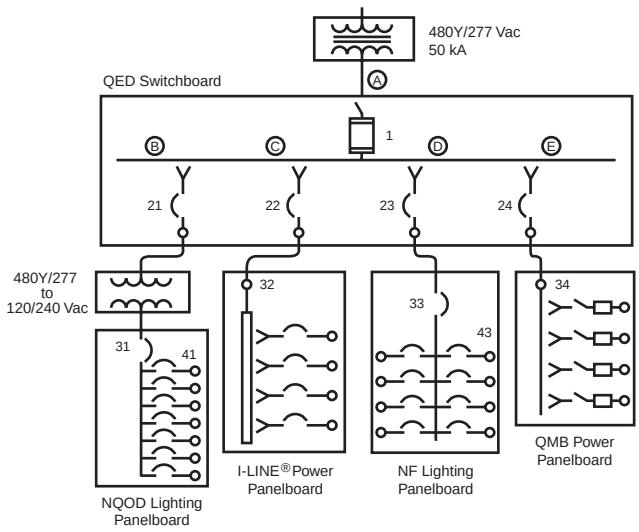
EXAMPLES

The following examples are based on a 480Y/277 V system with 50 kA available at the service entrance. Refer to the Figure 1 below.

Letter	Description
A	A main may be series-rated with all the distribution circuit breakers (21, 22, 23, 24). Calculating the available fault current at the line terminals of the downstream circuit breakers may permit lower AIR rated circuit breakers. Series rating at this level typically is not as economical as series rating between the switchboard distribution circuit breakers (22, 23) and panelboards (32, 33).
B	A distribution circuit breaker (21) is not series-rated through a transformer to a lighting panelboard (31) because the voltage changes.
C	A 225 A KC circuit breaker (22) will series rate with FD and FG circuit breakers in an I-LINE® panelboard (32). Refer to Table 8 on page 10.
D	The 225 A KC feeder circuit breaker (23) in the switchboard must be fully rated. A 225 A main circuit breaker (33) in the panelboard must be fully rated for the available fault current, either calculated at the panelboard or the switchboard available fault rating if calculations are not done. The integral panelboard main circuit breaker must series rate with the branch EDB circuit breakers (43). Refer to Table 10 on page 12.
E	Fusible disconnects with Class R, J, T, or L (34) do not require series rating with a 225 A KC circuit breaker (24).
	If a consultant specifies, based on a short-circuit study, that all switchboards are to be rated 50 kA, power panelboards 42 kA, and lighting panelboards 22 kA, the following procedure is permissible: • Series rate the switchboard main fusible disconnect (1) with the switchboard feeder circuit breakers (21, 22, 23, 24) at 50 kA. • Series rate the NQOD panelboard main circuit breaker (31) with the panelboard branch circuit breaker (41) at 22 kA. • Series rate the NF panelboard main circuit breaker (33) with the lighting panelboard branch circuit breakers (43) at 22 kA.

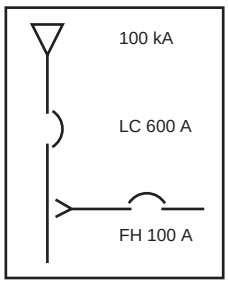
NOTE: Series-rated systems must comply with NEC Article 240.86(B).

Figure 1: Series Rating Example



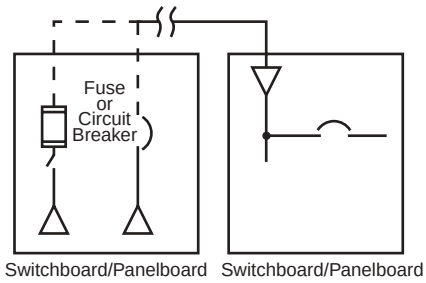
Example 1

A series-connected rating can be used *within* a single switchboard or panelboard enclosure.



Example 2

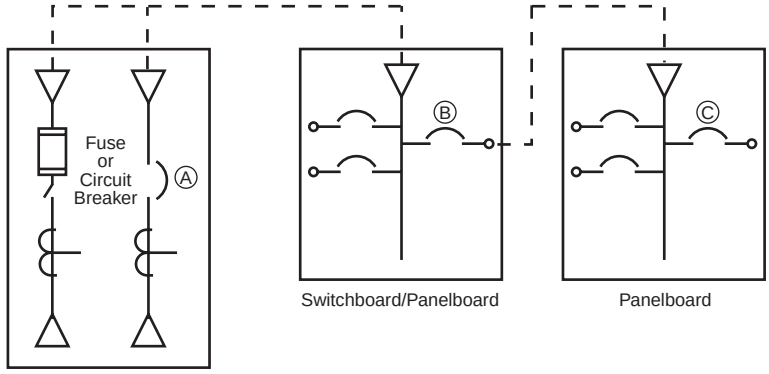
A series-connected rating can be accomplished outside a single enclosure using two switchboards, two panelboards, or a switchboard feeding a panelboard.



Example 3

A series-connected rating can be accomplished using a switchboard OCPD (A) and a panelboard main disconnect (B) (two-tier), or using a panelboard main OCPD (B) and a panelboard branch OCPD (C) (two-tier). In order for all OCPDs (A, B, C) to be in a series combination (three-tier), the series combination would have to be marked on the panelboard housing OCPD (C).

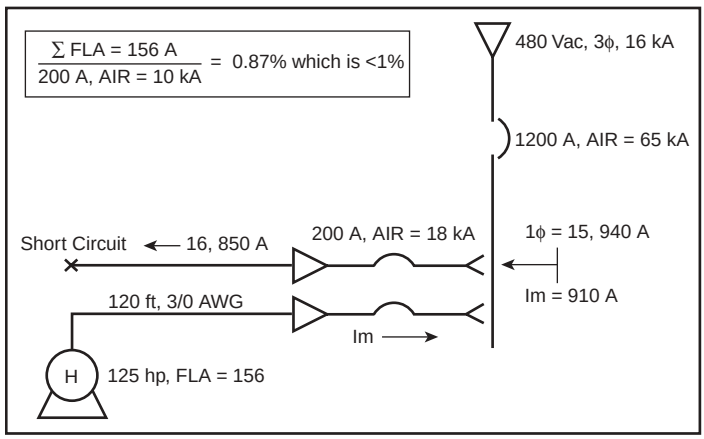
NOTE: Square D has three-tier ratings for multi-metering equipment. Multi-metering three-tier series ratings are not addressed in this bulletin. Applicable ratings appear on the appropriate equipment.



Example 4

Motor contribution in accordance with NEC 240.86 (B) must be considered before series ratings are permitted to be used.

NOTE: Use only the UL Listed SCCRs marked on the equipment. Standard interrupting circuit breakers cannot be substituted where high interrupting circuit breakers are indicated. Do not use the "up-over-down" method. It can lead to unsafe applications. Fuses chosen by the "up-over-down" method typically result in larger ampere ratings than the UL Listed fuse/circuit breaker series-connected short-circuit ratings shown in the tables. This simple method gives inaccurate results, partly because it ignores the dynamic impedance of molded case circuit breakers.



INTERRUPTING AND SERIES RATINGS

Table 1 shows the ratings of the OCPDs commonly furnished in Square D switchboards and I-LINE® panelboards. Devices are UL Listed for the interrupting ratings shown. Information given is correct at time of printing; ratings may change without notice due to modification in equipment design.

Table 1: Molded Case Circuit Breaker Interrupting Ratings (x 1000 RMS Symmetrical Amperes)

Circuit Breaker Type	Poles	Ampere Rating	240 Vac	277 Vac	480 Vac	600 Vac
FY	1	15–30	14	14	—	—
FA 240 V	1, 2, 3	15–100	10	—	—	—
FA 480 V	1	15–100	18	18	—	—
	2, 3	15–100	25	18	18	—
FA 600 V	2, 3	15–100	25	18	18	14
FH	1	15–30	65	65	—	—
	1	35–100	25	25	—	—
	2, 3	15–100	65	25	25	18
FC	2, 3	15–100	100	65	65	—
FI	2, 3	20–100	200	200	200	100
FD	1	15–70	18	18	18 [1]	—
	2, 3	15–100	25	18	18 [1]	—
FG	1	15–70	35	35	35 [1]	—
	2, 3	15–100	65	35	35 [1]	—
FJ	1	15–70	65	65	65 [1]	—
	2, 3	15–100	100	65	65 [1]	—
QB	2, 3	70–225	10	—	—	—
QD	2, 3	70–225	25	—	—	—
QG	2, 3	70–225	65	—	—	—
QJ	2, 3	70–225	100 [2]	—	—	—
KA	2, 3	70–250	42	25	25	22
KH	2, 3	70–250	65	35	35	25
KC	2, 3	110–250	100	65	65	—
KI	2, 3	110–250	200	200	200	100
LA	2, 3	125–400	42	30	30	22
LH	2, 3	125–400	65	35	35	25
LC	2, 3	300–600	100	65	65	35
LX	2, 3	100–600	100	65	65	35
LE	2, 3	100–600	100	65	65	35
LXI	2, 3	100–600	200	200	200	100
LI	2, 3	300–600	200	200	200	100
MA	2, 3	300–1200	42	30	30	22
MH	2, 3	300–1200	65	65	65	25
MX	2, 3	450–800	65	65	65	25
ME	2, 3	450–800	65	65	65	25
NA	2, 3	600–1200	100	50	50	25
NC	2, 3	600–1200	125	100	100	65
NX	2, 3	600–1200	125	100	100	65
NE	2, 3	600–1200	125	100	100	65
PA	2, 3	600–2000	65	50	50	42
PH	2, 3	600–2000	125	100	100	65
PC	2, 3	1600–2500	125	100	100	65
PX	3	600–2500	125	100	100	65
PE	3	600–2500	125	100	100	65
PG	2, 3	250–1200	65	35	35	18
PJ	2, 3	250–1200	100	65	65	25
PL	2, 3	250–1200	125	100	100	—
RG	2, 3	600–2500	65	35	35	18
RJ	2, 3	600–2500	100	65	65	25
RL	2, 3	600–2500	125	100	100	50
SE	3	200–4000	150	100	100	85

Continued on next page

[1] FD, FG, and FJ circuit breakers are rated 480Y/277 Vac maximum.

[2] QJ 3-pole circuit breaker is rated 100 kA, 208Y/120 Vac maximum.

Table 1: Molded Case Circuit Breaker Interrupting Ratings (x 1000 RMS Symmetrical Amperes)

Circuit Breaker Type	Poles	Ampere Rating	240 Vac	277 Vac	480 Vac	600 Vac
NT-N	3	100–1200	65	50	50	35
NT-H	3	100–1200	100	65	65	—
NT-L	3	100–1200	200	100	100	—
NW-N	3	100–2000	65	65	65	50
NW-H	3	100–6000	100	100	100	85
NW-L	3	100–6000	200	150	150	100

[1] FD, FG, and FJ circuit breakers are rated 480Y/277 Vac maximum.

[2] QJ 3-pole circuit breaker is rated 100 kA, 208Y/120 Vac maximum.

Table 2 shows the ratings of the OCPDs commonly furnished in Square D lighting and appliance panelboards. Devices are UL Listed for the interrupting ratings shown. Information given is correct at time of printing; ratings may change without notice due to equipment design modifications.

Table 2: Molded Case Circuit Breaker Interrupting Ratings (x 1000 RMS Symmetrical Amperes)

Circuit Breaker Type [1]	Poles	Ampere Rating	120 Vac	120/240 Vac	240 Vac	277 Vac	480/277 Vac
QO	1	10–70	10	10	—	—	—
	2	10–125	10	10	—	—	—
	3	10–100	10	10	10	—	—
QO-H	2	15–100	10	10	10	—	—
QO-VH	1	15–30	22	22	—	—	—
	2	15–125	22	22	—	—	—
	3	15–100	22	22	22	—	—
QH	1	15–30	65	65	—	—	—
	2	15–30	65	65	—	—	—
	3	15–30	65	65	65	—	—
QO-GFI	1	15–30	10	—	—	—	—
	2	15–60 [1]	10	10	—	—	—
QO-VHGFI	1	15–30	22	—	—	—	—
EDB	1	15–70	25	18	18	18	—
	2, 3	15–125	25	25	25	18	18
EGB	1	15–70	65	35	35	35	—
	2, 3	15–125	65	65	65	35	35
EJB	1	15–70	100	65	65	65	—
	2, 3	15–125	100	100	100	65	65

[1] 60 A QO-GFI is suitable only for feeding 120/240 Vac and 208 Vac 2-wire loads. It does not contain a load neutral connection.

Commercial Multi-Metering Switchboards (Class 2755 or Class 2756)

The OCPD within commercial metering switchboards, up to 100 kA, will be the *remote* line side main for the series combination. The load side circuit breaker will be in the panelboard, load center, or enclosed circuit breaker. This represents a typical two-tier system. All of the following tables apply.

NOTE: The marking will be on the downstream device, not on the commercial multi-metering switchboard; therefore, Tables 1–13 apply to series ratings with the devices in the commercial multi-metering switchboard. Exception: If a panelboard is installed within the commercial multi-metering switchboard, then the panelboard will be marked accordingly and per the tables listed in this bulletin.

Figure 2: UL Recognized Fuse/Circuit Breaker Series-Connected Rating

Figure 2, Table 3, and Table 4 show the arrangement and ratings of 240 Vac (maximum) systems with line side fuses in series with load side circuit breakers for switchboards and panelboards. ■

■ The line side fused switch may be in a separate enclosure or in the same enclosure as the load side circuit breaker. A line side fused switch may be integral or remote. A load side circuit breaker may be a branch or feeder. The series combination SCCR must not exceed that of the line side fused switch. The tables apply to Square D load side circuit breakers only. However, the line side fuse ratings are independent of the fuse manufacturer. For fuse information, refer to Table 11 on page 13. UL fuse/circuit breaker series ratings are not applicable to corner-grounded systems.

Table 3: 240 Vac Series-Connected Ratings (100 kA Maximum) [1]

Line Side		Load Side								
Fuse Class [2]	**Fuse Class Amps**	**FA 15–100 A**	**FH 15–100 A**	**QD/QG [3] 70–225 A**	**KA 70–250 A**	**KH 70–250 A**	**LA/LH 125–400 A**	**MA/MH 300–800 A**	**MX 450–800 A**	**PG 250–1200 A**
R	200 A	—	2, 3	2, 3	2, 3	2, 3	[4]	—	—	—
	400 A	—	2, 3	2, 3	2, 3	2, 3	2, 3	[4]	—	2, 3
	600 A	—	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[4]	2, 3
T 300 V	800 A	—	—	2, 3	—	—	—	—	—	2, 3
T 600 V	400 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[4]	—	2, 3
	600 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3
	800 A	—	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3
J	200 A	2, 3	2, 3	2, 3	2, 3	2, 3	[4]	—	—	—
	400 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[4]	—	2, 3
	600 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[4]	2, 3
L	800 A	—	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3
	1200 A	—	2, 3	2, 3	—	2, 3	2, 3	2, 3	2, 3	2, 3
	1600 A	—	—	—	—	2, 3	—	2, 3	2, 3	2, 3
	2000 A	—	—	—	—	2, 3	—	2, 3	2, 3	2, 3

1 Ratings are not available for areas with a dash (—); 2, 3 indicates the number of poles.

2 The fuse used in this UL test is an envelope (umbrella) fuse. This fuse is designed as a "worst case" fuse. Therefore, no matter which manufacturer's fuse is used, the Square D circuit breaker is protected.

3 A 3-pole circuit breaker can be used only on 208Y/120 Vac maximum.

4 Ratings are available, but not typically used with these combinations.

Table 4: 240 Vac Series-Connected Ratings (200 kA Maximum) [1]

Line Side		Load Side													
Fuse Class [2]	**Fuse Class Amps**	**FA 15–100 A**	**FH 15–100 A**	**FC 15–100 A**	**KA 70–250 A**	**KH 70–250 A**	**KC 110–250 A**	**LA/LH 125–400 A**	**LC 300–600 A**	**LX 100–600 A**	**MA/MH 300–800 A**	**MX 450–800 A**	**NA/NC 600–1200 A**	**NX 600–1200 A**	**PG, PJ, PL 250–1200 A**
R	200 A	—	2, 3	2, 3	—	2, 3	2, 3	[3]	[3]	[3]	[3]	[3]	[3]	[3]	—
	400 A	—	2, 3	2, 3	—	2, 3	2, 3	2, 3	[3]	2, 3	[3]	[3]	[3]	[3]	2, 3
	600 A	—	2, 3	2, 3	—	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[3]	[3]	[3]	2, 3
T 300 V	800 A	—	—	—	—	—	—	—	—	—	—	—	—	—	2, 3
T 600 V	400 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[3]	2, 3	[3]	—	—	—	2, 3
	600 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[3]	[3]	[3]	2, 3
	800 A	—	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[3]	[3]	2, 3
J	200 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[3]	—	[3]	—	—	—	—	—
	400 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[3]	2, 3	[3]	—	—	—	2, 3
	600 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[3]	[3]	[3]	2, 3
L	800 A	—	2, 3 [4]	2, 3	—	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3
	1200 A	—	—	2, 3	—	2, 3	2, 3	—	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3
	1600 A	—	—	—	—	—	—	—	—	—	—	—	2, 3	2, 3	2, 3 [5]
	2000 A	—	—	—	—	—	—	—	—	—	—	—	2, 3	2, 3	2, 3 [5]

1 Ratings are not available for areas with a dash (—); 2, 3 indicates the number of poles.

2 The fuse used in this UL test is an envelope (umbrella) fuse. This fuse is designed as a "worst case" fuse. Therefore, no matter which manufacturer's fuse is used, the Square D circuit breaker is protected.

3 Ratings are available, but not typically used with these combinations.

4 Not available in QED switchboard construction.

5 Rating not available with PG circuit breaker.

Figure 3: UL Recognized Fuse/Circuit Breaker Series-Connected Rating

Figure 3, Table 5, and Table 6 show the arrangement and ratings of 480 Vac (maximum) systems with line side fuses in series with load side circuit breakers for switchboards and panelboards.■

■ The line side fused switch may be in a separate enclosure or in the same enclosure as the load side circuit breaker. A line side fused switch may be integral or remote. A load side circuit breaker may be a branch or feeder. The series combination SCCR must not exceed that of the line-side fused switch. The tables apply to Square D load side circuit breakers only. However, the line side fuse ratings are independent of the fuse manufacturer. For fuse information, refer to Table 11 on page 13. UL fuse/circuit breaker series ratings are not applicable to corner-grounded systems.

Table 5: 480 Vac Series-Connected Ratings (100 kA Maximum) [1]

Line Side		Load Side													
Fuse Class [2]	Fuse Class Amps	FA 15–100 A	FH 15–100 A	FC 15–100 A	KA 70–250 A	KH 70–250 A	KC 110–250 A	LA/LH 125–400 A	LC 300–600 A	LX 100–600 A	MA/MH 300–800 A	MX 450–800 A	NA/NC 600–1200 A	NX 600–1200 A	PG, PJ, PL 250–1200 A
R	200 A	—	—	2, 3	2, 3 [3]	2, 3	2, 3	[4]	—	[4]	—	—	—	—	—
	400 A	—	—	2, 3	2, 3 [3]	2, 3	2, 3	2, 3	[4]	2, 3	[4]	[4]	—	—	2, 3
	600 A	—	—	2, 3	2, 3 [3]	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[4]	[4]	2, 3
T 600 V	400 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[4]	2, 3	[4]	[4]	—	—	2, 3
	600 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[4]	[4]	2, 3
	800 A	—	—	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3
J	200 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[4]	—	[4]	—	—	—	—	—
	400 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[4]	2, 3	[4]	[4]	—	—	2, 3
	600 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[4]	[4]	2, 3
L	800 A	—	—	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3
	1200 A	—	—	2, 3	—	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3
	1600 A	—	—	2, 3	—	—	2, 3	—	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3
	2000 A	—	—	2, 3	—	—	2, 3	—	2, 3	2, 3	—	2, 3	2, 3	2, 3	2, 3

1 Ratings are not available for areas with a dash (—); 2, 3 indicates the number of poles.

2 The fuse used in this UL test is an envelope (umbrella) fuse. This fuse is designed as a "worst case" fuse. Therefore, no matter which manufacturer's fuse is used, the Square D circuit breaker is protected.

3 Not available in QED switchboard construction.

4 Ratings are available, but not typically used with these combinations.

Table 6: 480 Vac Series-Connected Ratings (200 kA Maximum) [1]

Line Side		Load Side													
Fuse Class [2]	Fuse Class Amps	FA 15–100 A	FH 15–100 A	FC 15–100 A	KA 70–250 A	KH 70–250 A	KC 110–250 A	LA/LH 125–400 A	LC 300–600 A	LX 100–600 A	MA/MH 300–800 A	MX 450–800 A	NA/NC 600–1200 A	NX 600–1200 A	PG, PJ, PL 250–1200 A
R	200 A	—	—	2, 3	—	—	2, 3	[3]	—	[3]	—	—	—	—	—
	400 A	—	—	2, 3	—	—	2, 3	2, 3	[3]	2, 3	[3]	—	—	—	2, 3
	600 A	—	—	2, 3	—	—	2, 3	2, 3	2, 3	2, 3	2, 3	[3]	[3]	[3]	2, 3
T 300 V	800 A	—	—	—	—	—	—	—	—	—	—	—	—	—	2, 3
T 600 V	400 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[3]	2, 3	[3]	—	—	—	—
	600 A	—	—	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[3]	[3]	[3]	—
	800 A	—	—	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3
J	200 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[3]	—	[3]	—	—	—	—	—
	400 A	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[3]	2, 3	[3]	—	—	—	2, 3
	600 A	—	—	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	[3]	[3]	[3]	2, 3
L	800 A	—	—	2, 3	—	—	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3
	1200 A	—	—	2, 3	—	—	2, 3	—	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3	2, 3
	1600 A	—	—	—	—	—	—	—	—	—	—	—	2, 3	2, 3	—
	2000 A	—	—	—	—	—	—	—	—	—	—	—	2, 3	2, 3	—

1 Ratings are not available for areas with a dash (—); 2, 3 indicates the number of poles.

2 The fuse used in this UL test is an envelope (umbrella) fuse. This fuse is designed as a "worst case" fuse. Therefore, no matter which manufacturer's fuse is used, the Square D circuit breaker is protected.

3 Ratings are available, but not typically used with these combinations.

Figure 4: UL Recognized Circuit Breaker/Circuit Breaker Series-Connected Rating

Figure 4 and Table 7 show the arrangement and ratings of 240 or 277 Vac (maximum) systems with line side circuit breakers in series with load side circuit breakers for I-LINE switchboards and panelboards. ■

■ The line side circuit breaker may be in a separate enclosure or in the same enclosure as the load side circuit breaker. A line side circuit breaker may be integral or remote. A load side circuit breaker may be a branch or feeder. The series-connected SCCR must not exceed that of the line side circuit breaker. The tables apply to Square D load side circuit breakers only. Not applicable to corner-grounded systems.

Table 7: I-LINE 240 Vac and 277 Vac Series Ratings—Switchboards/Panelboards

Maximum System Voltage	Maximum SCCR	Line Side		Load Side		
		Main Circuit Breaker	Maximum Circuit Breaker	Circuit Breakers [1]	Current Rating (A)	Poles
120 Vac	100 kA	FJ	100	FD	15–70	1
		QJ	225	FD	15–70	
		QJ	225	FA	15–100	
	65 kA	QG	225	FA	15–100	
				FD	15–70	
208Y/120	100 kA	QJ	225	FA, FD	15–100	2, 3
		QJ	225	QD, QG	70–225	2, 3
		PH	1600			
		PJ	1200			
		RJ	2000			
240 Vac	42 kA	KA	250	FD	15–100	1, 2, 3
		LA	400	QD	70–225	2, 3
		MA	1200			
	65 kA	FG, FH	100	FD	15–100	1, 2, 3
		MX	800			
		MH	1000			
		PJ	1200			
		FC	100	FD, FG		
		KC, KH	250			
		LH	400			
		LC	600			
		QG	225	FA, FD	15–100	2, 3
				QD	70–225	
		LH	400	QD	70–225	
		MH	1200			
		PA	1600			
		PG	1200			
		RG	2000			
	85 kA	RL	2500	FH	15–100	2, 3
			2500	KH	70–250	

Continued on next page

Table 7: I-LINE 240 Vac and 277 Vac Series Ratings—Switchboards/Panelboards

Maximum System Voltage	Maximum SCCR	Line Side		Load Side		
		Main Circuit Breaker	Maximum Circuit Breaker	Circuit Breakers [1]	Current Rating (A)	Poles
240 Vac	100 kA	FC	100	FD, FG, FJ	15–100	1
		KC	250			
		LC, LX	600			
		QJ	225	FD	15–100	2
		FC	100	FA, FD, FG, FH, FJ	15–100	2, 3
		PH	1600	QD, QG	70–225	
		RJ	1200			
		FJ	100	FD	15–100	
		KC	250	FA, FD, FG, FH, FJ		
		LC, LX	600	FD, FG, FH, FJ		
		KC	250	KA, KH	70–250	
		LC, LX	600			
		LC, LX	600	LA, LH	125–400	
	125 kA	RL	2500	RG	600–2500	
	200 kA	FI	100	FD, FG, FJ	15–100	1
		KI	250			
		LI, LXI	600			
		FI, KI	100, 250	FA, FC, FD, FG, FH, FJ	15–100	2, 3
		LI, LXI	600	FC, FD, FG, FH, FJ		
		KI	250	QD, QG, QJ	70–225	
		LI	600			
		LXI	600			
		KI	250	KA, KC, KH	70–250	
		LI, LXI	600	LA, LH, LC	125–400	
		LI, LXI	600	KA, KC, KH	70–250	
277 Vac	25 kA	FH	100	FD	15–70	1
		KA	250			
	35 kA	FG	100	FD	15–70	
		KH	250			
		LH	400			
	65 kA	FC	100	FA, FD, FG, FH, FY	15–30	
		FJ	100	FD		
		KC	250	FA, FD, FG, FH, FY	15–100	
					15–70	
		LC, LX (400 A, Max)	400	FH	15–30	
		LC, LX (600 A, Max)	600	FY	15–30	
				FD, FG	15–70	
	200 kA	FI	100	FA, FD, FG, FH, FJ, FY	15–30	
		KI	250		15–100	
					15–70	
		LI, LXI (400 A, Max)	400	FH	15–30	
		LI, LXI (600 A, Max)	600	FY	15–30	
				FD, FG, FJ	15–70	

[1] FD, FG, FJ circuit breaker ratings apply to both switchboards and panelboards. Ratings for all other circuit breakers apply only to switchboards.

Figure 5: UL Recognized Circuit Breaker/Circuit Breaker Series-Connected Rating

Figure 5 and Table 8 show the arrangement and ratings of 480 Vac (maximum) systems with line side circuit breakers in series with load side circuit breakers for I-LINE switchboards and panelboards. ■

■ The line side circuit breaker may be in a separate enclosure or in the same enclosure as the load side circuit breaker. A line side circuit breaker may be integral or remote. A load side circuit breaker may be a branch or feeder. The series-connected SCCR must not exceed that of the line side circuit breaker. The tables apply to Square D load side circuit breakers only. Not applicable to corner-grounded systems.

Table 8: I-LINE 480 Vac Series Ratings—Switchboards/Panelboards

Maximum System Voltage	Maximum SCCR	Line Side		Load Side		
		Main Circuit Breaker	Maximum Circuit Breaker	Circuit Breakers [1]	Current Rating (A)	Poles
480/277 Vac	25 kA	FH	100	FD	15–100	2, 3
		KA	250			
480 Vac	30 kA	KH	250	FH	15–100	2, 3
		LA	400			
		MA	1000			
		MX	800			
		PJ	1200			
		PA, PC	2000			
		PX	2500			
		LA	400	KA	70–250	
		MA	1000			
		MX	800			
		PA, PC	2000			
		PX	2500			
480/277 Vac	35 kA	FG	100	FD	15–100	2, 3
		KH	250			
		LH	400			
	65 kA	FJ	100	FD	15–100	
		FC, KC	100, 250	FD, FG		
480 Vac	65 kA	FC, KC	100, 250	FA, FH	15–100	2, 3
		LC, LX (400 A, Max)	400	FH	15–100	
480/277 Vac	65 kA	LC, LE, LX (600 A, Max)	600	FD, FG	15–100	2, 3
480 Vac	65 kA	KC	250	KA, KH	70–250	2, 3
		LC, LX	600			
		LC, LX	600	LA, LH	125–400	
	100 kA	LI, LXI (600 A, Max)	600	KA, KH	70–250	
		RL	2500	RG	600–2500	
	200 kA	FI, KI	100, 250	FA, FC, FH	15–100	
480/277 Vac	200 kA	FI, KI	100, 250	FD, FG, FJ	15–100	2, 3
480 Vac	200 kA	LI, LXI (400 A, Max)	400	FC, FH	15–100	2, 3
480/277 Vac	200 kA	LI, LXI (600 A, Max)	600	FD, FG, FJ	15–100	2, 3
480 Vac	200 kA	KI	250	KA, KC, KH	70–250	2, 3
		LI, LXI (400 A, Max)	400			
		LI, LXI (600 A, Max)	600	FC	15–100	
				KC	70–250	
		LI, LXI	600	LA, LH	125–400	
				LC	300–600	

[1] FD, FG, FJ circuit breaker ratings apply to both switchboards and panelboards. Ratings for all other circuit breakers apply only to switchboards.

Figure 6: UL Recognized Circuit Breaker/Circuit Breaker Series-Connected Rating

Figure 6 and Table 9 on page 11 show the arrangement and ratings of 240 Vac (maximum) systems with line side circuit breakers in series with load side circuit breakers for NQOD panelboards. ■

■ Suffixes HID, SWD, and SWN may also be applied to the applicable branch circuit breakers shown above; except suffix SWN may not be applied in combination with LC main circuit breakers.

Table 9: NQOD 240 Vac Series Short-Circuit Current Ratings—Panelboards

Maximum System Voltage [1]	Maximum SCCR	Integral or Remote Main Circuit Breakers and Remote Main Fuses	Branch Circuit Breakers [2] [3]			
			Type	1-Pole	2-Pole	3-Pole
208Y/120 Vac	100 kA	QJ	QO(B)	15–70 A	15–125 A	15–30 A
			QO (B) AS	15–30 A	15–30 A	15–30 A
			QO (B) GF I	15–30 A	15–60 A	—
			QO (B) -VH	—	150	35–150 A
			QO (B) -PL	15–30 A	15–60 A	15–30 A
			QO-AFI	15–20 A	—	—
240 Vac	22 kA	QO(B)-VH	QO(B)	15–70 A	15–125 A	15–100 A
			QO (B) AS	15–30 A	15–30 A	15–30 A
			QO (B) GF I	15–30 A	15–60 A	—
			QO (B) PL	15–30 A	15–30 A	—
	22 kA	Q2-H	QO(B)	15–70 A	15–100 A	15–30 A
			QO (B) GF I	15–30 A	15–30 A	—
	25 kA	QD	QO(B)	15–70 A	15–125 A	15–30 A
			QO (B) AS	15–30 A	15–30 A	15–30 A
			QO (B) GF I	15–30 A	15–60 A	—
			QO (B) -VH	—	150	35–150 A
			QO (B) -PL	15–30 A	15–60 A	15–30 A
			QO-AFI	15–20 A	—	—
	25 kA	ED, FD	QO(B)	15–70 A	15–125 A	15–100 A
			QO (B) GF I	15–30 A	15–60 A	—
	25 kA	KD	QO(B)	15–70 A	15–125 A	15–100 A
			QO (B) AS	15–30 A	15–30 A	15–30 A
			QO (B) GF I	15–30 A	15–60 A	—
	42 kA	LA, MA	Q2L-H	—	110–225 A	110–225 A
			QD	—	70–225 A	70–225 A
	42 kA	LC [4, 5]	QO(B)	15–70 A [4]	—	—
			QO (B) VH	15–30 A	15–125 A	15–100 A (3P 208 V Max.)
			QO (B) GF I	15–30 A [5]	15–60 A	—
	65 kA	LC [4, 5]	QO(B)	15–30 A	—	—
			QO (B) VH	15–30 A	15–125 A	15–100 A (3P 208 V Max.)
			QO (B) GF I	15–30 A [5]	—	—
240 Vac	65 kA	EG, FG, KG	QO(B)	15–70 A	15–125 A	15–100 A
			QO (B) GF I	15–30 A	15–60 A	—
	65 kA	QG	QO(B)	15–70 A	15–125 A	15–30 A
			QO (B) AS	15–30 A	15–30 A	15–30 A
			QO (B) GF I	15–30 A	15–60 A	—
			QO (B) -VH	—	150	35–150 A
			QO (B) -PL	15–30 A	15–60 A	15–30 A
			QO-AFI	15–20 A	—	—
	65 kA	FCL22 . . . . KCL22 . . . . FCL32 . . . . KCL32	QO(B) QO (B) AS QO (B) GF I	15–70 A 15–30 A 15–30 A	15–100 A 15–30 A 15–30 A	15–100 A 15–30 A —
	100 kA	FCL24 . . . . KCL24 . . . . FCL34 . . . . KCL34				
	100 kA	EJ, FJ	QO(B)	15–70 A	15–125 A	15–100 A
			QO (B) GF I	15–30 A	15–60 A	—
	200 kA	FI, KI	QO(B)	15–70 A	15–125 A	15–100 A
			QO (B) AS	15–30 A	15–30 A	15–30 A
			QO (B) GF I	15–30 A	15–60 A	—
	200 kA	Maximum Fuses 200 A Class J or T6	QO(B)	15–70 A	15–125 A	15–100 A
			QO (B) AS	15–30 A	15–30 A	15–30 A
			QO (B) GF I	15–30 A	15–60 A	—

1 For shown circuit breakers rated less than this maximum voltage, the indicated SCCR also applies, but at the voltage rating of the circuit breaker.

2 Suffixes HID, SWD, and SWN may also be applied to the applicable branch circuit breakers shown above; except suffix SWN may not be applied in combination with LC main circuit breakers.

3 Where QO (B) circuit breakers are shown above, QO (B) H, QO (B) VH, and QH (B) circuit breakers may also be used.

4 Indicates only 15–30 A circuit breakers may be used when the LC circuit breaker is rated 450 A, 500 A, or 600 A.

5 Indicates circuit breakers may not be used when the LC circuit breaker is rated 450 A, 500 A, or 600 A.

Figure 7: UL Recognized Circuit Breaker/Circuit Breaker Series-Connected Rating

Figure 7 and Table 10 show the arrangement and ratings of systems with line-side circuit breakers in series with load side circuit breakers for NF panelboards. ■

■ The line side circuit breaker may be in a separate enclosure or in the same enclosure as the load side circuit breaker. A line side circuit breaker may be integral or remote. A load side circuit breaker may be a branch or feeder. The series-connected SCCR must not exceed that of the line side circuit breaker. The table applies to Square D load side circuit breakers only. Not applicable to corner-grounded systems.

Table 10: NF Panelboard Series Ratings—Standard and Column Width

Maximum System Voltage	Maximum SCCR	Line Side Circuit Breaker	Load Side Circuit Breaker	Poles
120 Vac 120/240 Vac 240 Vac	65 kA	EG, FH, FG, KH, LH, MH, MX	EDB	1, 2, 3
		EG	ECB-G3	
	100 kA	EJ, FC, FJ, KC, LC, LX	EDB, EGB	1, 2, 3
		EJ, FC, KC	ECB-G3	
	200 kA	FI, KI, LI, LXI	EDB, EGB, EJB	1, 2, 3
		FI, KI	ECB-G3	
480Y/277 Vac	35 kA	EG, FG, KH, LH	EDB	1, 2, 3
		EG	ECB-G3	
	65 kA	EJ, FC, FJ, KC, LC, LX	EDB, EGB	1, 2, 3
		EJ, FC, KC	ECB-G3	
	200 kA	FI, KI, LI, LXI	EDB, EGB, EJB	1, 2, 3
		FI, KI	ECB-G3	
120 120/240 240	200 kA	Class J or T (600 V) 200 A Maximum Fuses	ECB-G3	1, 2, 3
480Y/277 Vac	100 kA	Class J or T (600 V) 400 A Maximum Fuses	EDB, EGB, EJB	1, 2, 3
	200 kA	Class J or T (600 V) 200 A Maximum Fuses		
	200 kA	Class J or T (600 V) 200 A Maximum Fuses	ECB-G3	

Table 11: Fuse Cross Reference [1]

UL Class	Voltage Rating (V)	Ampere Rating (A)	Interrupting Rating in RMS Symmetrical Amperes (kA)	Gould Shawmut	Reliance (Economy)	Bussman	Application
H	250 600	1–600	10	RF RFS	ERN ERS	REN RES	General purpose, renewable.
H or K5 [2]	250 600	1–600	10	OT OTS	KON KOS	NON NOS	General purpose.
RK5	250 600	1–600	200	TR-R TRS-R	ECNR ECNS	FRN-R FRS-R	Main, feeder, and branch circuits. Especially recommended for motors, welders, and transformers.
RK1	250 600	1–600	200	A2K-R A6K-R	NCLR SCLR	KTN-R KTS-R	Main, feeder, and branch circuits. Especially recommended for circuit breaker protection (high degree of current limitation).
RK1	250 600	1–600	200	A2D A6D	LENRK LESRK	LPN-RK LPS-RK	Main, feeder, and branch circuits. Circuit breaker protection.
J	600	1–600	200	A4J	JCL	LPJ	Main, feeder, and branch circuits. Circuit breaker protection.
T	300 600	1–1200	200	A3T	—	JJN JJS	Main, feeder, and branch circuits. Circuit breaker protection, small physical dimensions. Non-motor loads (no heavy inrush currents).
L	600	601–6000	200	A4BT	LCL	KRP-C [3]	High interrupting capacity main, feeder, and branch circuits; large motor circuit breaker.
L	600	601–6000	200	A4BY	LCU	KTU	High interrupting capacity main, feeder, and branch circuits; large motor circuit breaker.

1 This listing is intended as a comparative reference only. Some fuse characteristics may not be equal in all aspects to other fuses named. If necessary, check catalog data or request factory verification of specific features.

2 Some ampere ratings in the range of 60 A and smaller are available as UL Class K5 with a 50 kA interrupting rating, but are not current limiting.

3 Has more time delay than standard Class L.

SPEED-D® SERVICE SECTION SWITCHBOARDS (CLASS 2710)

The main or distribution device within these switchboards, up to 200 kA, will be the *remote* line side main for the series combination. Additional ratings are shown in Table 12 and Table 13 for circuit breakers located within the service section.

Table 12: Type SF Service Section Switchboards: Fusible Main with I-LINE or NQOD Distribution

Maximum System Voltage	Maximum SCCR	Line Side Class T Fuse Maximum Current Rating (A)	Load Side	
			Circuit Breaker	Poles
120/240 Vac	42 kA	400 (600 V)	QO-VH, QOB-VH	1
240 Vac	42 kA	800 (600 V)	QO-VH, QOB-VH	2, 3
			FA	
			Q4	
			Q2-H, QD	2
480 Vac	50 kA		FA, FH	2, 3
	65 kA		KA, KH	
			LA,LH	

Table 13: Type SB Service Section Switchboard: Main Circuit Breaker with I-LINE or NQOD Distribution

Maximum System Voltage	Maximum SCCR	line side Circuit Breaker	Load Side	
			Circuit Breaker	Poles
120 Vac	42 kA	LH	FY	1
		MH		
240 Vac	42 kA	LH	Q2-H, QD	2,. 3
			Q4	
		MH	Q2-H, QD	
			Q4	
480 Vac	30 kA	LH	FA	
			KA	
		MH	FH	
			KH	

Square D Company
232 North Tippecanoe
Peru, IN 46970 USA
1-888-SquareD (1-888-778-2733)
www.SquareD.com

Square D Series Rating Chart

I-Line Switchboard/Panelboard **(See Notes on Page 2)**

Maximum System Voltage	Maximum SCCR	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
240 Vac	100kA	LPN-RK	600	FH, KA, KH, LA, LH, MA, MH, MX	ALL	2, 3
		JJS	600	FA	ALL	2, 3
		JJS	800	FH, KA, KH, LA, LH, MA, MH, MX	ALL	2, 3
		LPJ	600	FA, FH, KA, KH, LA, LH, MA, MH, MX	ALL	2, 3
		KRP-C	800	KA	ALL	2, 3
		KRP-C	1200	FH, LA, LH	ALL	2, 3
		KRP-C	2000	KH, MA, MH, MX	ALL	2, 3
	200kA	LPN-RK	600	FH, FC, KH, KC, LA, LH, LC, LX, MA, MH, MX, NA, NC, NX	ALL	2, 3
		JJS	600	FA	ALL	2, 3
		JJS	800	FH, FC, KA, KH, KC, LA, LH, LC, LX, MA, MH, MX, NA, NC, NX	ALL	2, 3
		LPJ	600	FA, FH, FC, KA, KH, KC, LA, LH, LC, LX, MA, MH, MX, NA, NC, NX	ALL	2, 3
		KRP-C	800	FH, LA, LH	ALL	2, 3
		KRP-C	1200	FC, KH, KC, LC, LX, MA, MH, MX	ALL	2, 3
		KRP-C	2000	NA, NC, NX	ALL	2, 3
480 Vac	100kA	LPS-RK	600	FC, KA, KH, KC, LA, LH, LC, LX, MA, MH, MX, NA	ALL	2, 3
		JJS	600	FA, FH	ALL	2, 3
		JJS	800	FC, KA, KH, KC, LA, LH, LC, LX, MA, MH, MX, NA	ALL	2, 3
		LPJ	600	FA, FH, FC, KA, KH, KC, LA, LH, LC, LX, MA, MH, MX, NA	ALL	2, 3
		KRP-C	800	KA	ALL	2, 3
		KRP-C	1200	KH, LA, LH		
		KRP-C	1600	MA		
		KRP-C	2000	FC, KC, LC, LX, MH, MX, NA		
	200kA	LPS-RK	600	FC, KC, LA, LH, LC, LX, MA, MH, MX, NA, NC, NX	ALL	2, 3
		JJS	400	FA, FH	ALL	2, 3
		JJS	800	FC, KA, KH, KC, LA, LH, LC, LX, MA, MH, MX, NA, NC, NX	ALL	2, 3
		LPJ	400	FA, FH	ALL	2, 3
		LPJ	600	FC, KA, KH, KC, LA, LH, LC, LX, MA, MH, MX, NA, NC, NX	ALL	2, 3
		KRP-C	800	LA, LH	ALL	2, 3
		KRP-C	1200	FC, KC, LC, LX, MA, MH, MX	ALL	2, 3
		KRP-C	2000	NA, NC, NX	ALL	2, 3

Square D Series Rating Chart

NQOD Panelboards (See Notes Below)

Maximum System Voltage	Maximum SCCR	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
240 Vac	200kA	JJS, LPJ	200	QO, QOB	ALL	1, 2, 3
				QO, QOB (AS)	ALL	1, 2, 3
				QO, QOB (GF I)	ALL	1, 2, 3
		JJN	400	QO, QOB	ALL	1, 2, 3
				QO, QOB (AS)	ALL	1, 2, 3
				QO, QOB (GF I)	ALL	1, 2, 3

Note for NQOD Panelboards: 1P for use at 120V Only

NEHB Panelboards (See Notes Below)

Maximum System Voltage	Maximum SCCR	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
480Y/277 Vac	100kA	JJS, LPJ	200	EH, EHB	ALL	1, 2, 3

Note for NEHB Panelboards: 1P for use at 277V Only

NF Panelboard (See Notes Below)

Maximum System Voltage	Maximum SCCR	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
480Y/277 Vac	100kA	JJS, LPJ	400	EDB, EGB, EJB	ALL	1, 2, 3
	200kA	JJS, LPJ	200			

Note for NF Panelboards: 1P for use at 277V Only

SF Switchboards with I-Line or NQOD Distribution (See Notes Below)

Maximum System Voltage	Maximum SCCR	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
120/240 Vac	42kA	JJS	400	QO-VH, QOB-VH	ALL	1 (120V)
240 Vac	42kA	JJS	800	QO-VH, QOB-VH, FA, Q4	ALL	2, 3
				Q2-H	ALL	2
480 Vac	50kA	JJS	800	FA, FH	ALL	2, 3
	65kA	JJS	800	KA, KH, LA, LH	ALL	

NOTE (1): The data in these charts was compiled from information in Square D, Series Rating Data Bulletin No. 2700DB9901 and Square D Digest 171. Cooper Bussmann assumes no responsibility for the accuracy or reliability of the information. The information contained in the tables may change without notice due to equipment design modifications.

NOTE (2): The line-side fused switch may be in a separate enclosure or in the same enclosure as the load-side circuit breaker. A line-side fused switch may be integral or remote.

NOTE (3): Max fuse current rating denotes the largest amperage fuse that may be used for that series rated combination. A lower amperage fuse may be substituted for the listed fuse.

GE Series Rating Chart

Spectra Series

(See Notes on Page 4)

Maximum System Voltage	Maximum SCCR	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
240 Vac	42kA	JJN, LPJ	600	TJD	250-400	2, 3
		KRP-C	2000	TJD	250-400	2, 3
	100kA	LPJ, JJN	400	TQD	125-225	2, 3
			600	THHQB	40-100	3
				TQD	100-225	2
				TQD	125-225	3
			800	TJD	250-400	2, 3
		KRP-C	1200	SFH	70-250	2, 3
			2000	TJD	250-400	2, 3
			2500	THJK	250-600	2, 3
	200kA	LPN-RK	200	TEB, TED	15-100	1, 2, 3
				SFH, SFL	70-250	2, 3
				SED, SEH, SEL	15-150	2, 3
		LPJ, JJN	400	TEB	15-100	1, 2
				TEB, TED	15-100	2, 3
				TJD	250-400	2, 3
				SFH, SFL	70-250	2, 3
			600	SED, SEH, SEL	15-150	2, 3
		KRP-C	2000	SGD, SGH, SGL	125-600	2, 3
277Vac	100kA	LPS-RK	100	TED	15-50	1
				THED	15-30	1
				TEY	15-100	1
			200	SED, SEH, SEL	15-150	2, 3
				TEY	15-100	1
				TED	15-50	1
		LPJ, JJS	400	TED	15-50	1
				THED	15-30	1
				SED, SEH, SEL	15-150	2, 3
			600	TEY	15-100	1
				SED, SEH, SEL	15-150	2, 3
480 Vac	65kA	LPJ	600	TED, THED	15-150	2, 3
	100kA	LPS-RK	100	TED, THED6	15-100	2, 3
			200	TEY	15-100	2, 3
				SED, SEH, SEL	15-150	2, 3
				TED	15-50	1
		LPJ, JJS	400	TED, THED6	15-100	2, 3
				SFH, SFL	70-250	2, 3
				SGH, SGL	125-600	2, 3
			600	TEY	15-100	2, 3
				SED, SEH, SEL	15-150	2, 3
		JJS	800	SKH, SKL	300-1200	2, 3
		KRP-C	1200	THJK	125-600	2, 3
			2000	SKH, SKL	300-1200	2, 3
				SGH, SGL	125-600	2, 3
	200kA	KRP-C	2000	TPV, THPV	800A FRAME (1)	3
			2500	TPV, THPV	2500A FRAME (1)	3
600 Vac	200kA	KRP-C	2000	TPV, THPV	800A FRAME (1)	3
			2500	TPV, THPV	2500A FRAME (1)	3

(1) Includes all sensor/rating plug or setting values within stated frame size.

GE Series Rating Chart

AL / AQ PANELBOARD

(See Notes on Page 4)

Maximum System Voltage	Maximum SCCR	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
240 Vac	42kA	JJN	600	THQL-GF	15-30	1
				THQL	15-100 (2)	1, 2, 3
		JJN, LPJ	600	TJD	250-400	2, 3
		KRP-C	2000	TJD	250-400	2, 3
	65kA	JJN	600	THHQL	15-70	1
				THHQL	15-125	2
		JJN, LPJ, LPN-RK	600	TFJ	70-225	2, 3
		KRP-C	3000	TFJ	70-225	2, 3
	100kA	LPN-RK	200	THQL	15-100 (2)	1, 2, 3
		JJN	200	THQP	15-50	1, 2
		LPJ, JJN	400	THQL	15-100 (2)	1, 2, 3
				TQD	125-225	2, 3
			600	THHQL, THHQB	40-100	3
				TFJ	70-225	2, 3
				TQD	100-225	2
				TQD	125-225	3
			800	TJD	250-400	2, 3
		KRP-C	1200	TFJ	70-225	2, 3
				SFH	70-250	2, 3
			2000	TJD	250-400	2, 3
	200kA	LPN-RK	200	THQL	15-100 (2)	1, 2
				TFJ	70-200	2, 3
				SFH, SFL	70-250	2, 3
				SED, SEH, SEL	15-150	2, 3
		LPJ, JJN	400	THQL	15-100 (2)	1, 2
				TFJ	70-225	2, 3
				TJD	250-400	2, 3
				SFH, SFL	70-250	2, 3
			600	SED, SEH, SEL	15-150	2, 3
		KRP-C	2000	SGD, SGH, SGL	125-600	2, 3

(2) THQL 1 pole rating is 70 amperes maximum. Maximum system voltage is 120/240VAC.
THQL 2 pole 110-125A ratings are also series rated on 120/240VAC maximum services.

ALC / AQC Panelboard

(See Notes on Page 4)

Maximum System Voltage	Maximum SCCR	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
240 Vac	42kA	JJN	600	THQL-GF	15-30	1
				THQL	15-100 (2)	1, 2, 3
	65kA	JJN	600	THHQL	15-70	1
				THHQL	15-125	2
		JJN, LPJ, LPN-RK	600	TFJ	70-225	2, 3
		KRP-C	3000	TFJ	70-225	2, 3
	100kA	LPN-RK	200	THQL	15-100 (2)	1, 2, 3
		JJN	200	THQP	15-50	1, 2
		LPJ, JJN	400	THQL	15-100 (2)	1, 2, 3
				TQD	125-225	2, 3
			600	THHQL, THHQB	40-100	3
				TFJ	70-225	2, 3
				TQD	100-225	2
				TQD	125-225	3
		KRP-C	1200	TFJ	70-225	2, 3
				SFH	70-250	2, 3
	200kA	LPN-RK	200	THQL	15-100 (2)	1, 2
				TFJ	70-200	2, 3
				SFH, SFL	70-250	2, 3
				SED, SEH, SEL	15-150	2, 3
		LPJ, JJN	400	THQL	15-100 (2)	1, 2
				TFJ	70-225	2, 3
				SFH, SFL	70-250	2, 3
			600	SED, SEH, SEL	15-150	2, 3

(2) THQL 1 pole rating is 70 amperes maximum. Maximum system voltage is 120/240VAC.
THQL 2 pole 110-125A ratings are also series rated on 120/240VAC maximum services.

GE Series Rating Chart

AE / AD PANELBOARD

(See Notes on Page 4)

Maximum System Voltage	Maximum SCCR	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
277Vac	100kA	LPS-RK	100	TED	15-50	1
				THED	15-30	1
				TEY	15-100	1
			200	SED, SEH, SEL	15-150	2, 3
				TEY	15-100	1
				TED	15-50	1
		LPJ, JJS	400	TED	15-50	1
				THED	15-30	1
				SED, SEH, SEL	15-150	2, 3
			600	TEY	15-100	1
				SED, SEH, SEL	15-150	2, 3
480 Vac	65kA	LPJ	600	TED, THED	15-150	2, 3
	100kA	LPS-RK	100	TED, THED6	15-100	2, 3
			200	TEY	15-100	2, 3
				SED, SEH, SEL	15-150	2, 3
				TED	15-50	1
		LPJ, JJS	400	TED, THED6	15-100	2, 3
				TFJ	70-225	2, 3
				TJJ	125-400	2, 3
				SFH, SFL	70-250	2, 3
				SGH, SGL	125-600	2, 3
			600	TEY	15-100	2, 3
				SED, SEH, SEL	15-150	2, 3
		JJS	800	SKH, SKL	300-1200	2, 3
		KRP-C	1200	TJJ	125-400	2, 3
			2000	SKH, SKL	300-1200	2, 3
				SGH, SGL	125-600	2, 3

AEC PANELBOARD

(See Notes on Page 4)

Maximum System Voltage	Maximum SCCR	Line Side Fuse	Max Fuse Current Rating	Load Side		
				Circuit Breaker	Amps	Poles
277Vac	100kA	LPS-RK	100	TED	15-50	1
				TEY	15-100	1
			200	SED, SEH, SEL	15-150	2, 3
				TEY	15-100	1
				TED	15-50	1
		LPJ, JJS	400	TED	15-50	1
				SED, SEH, SEL	15-150	2, 3
			600	TEY	15-100	1
				SED, SEH, SEL	15-150	2, 3
480 Vac	65kA	LPJ	600	TED	15-150	2, 3
	100kA	LPS-RK	100	TED	15-100	2, 3
			200	TEY	15-100	2, 3
				SED, SEH, SEL	15-150	2, 3
				TED	15-50	1
		LPJ, JJS	400	TED	15-100	2, 3
				TFJ	70-225	2, 3
				SFH, SFL	70-250	2, 3
				SGH, SGL	125-600	2, 3
			600	TEY	15-100	2, 3
				SED, SEH, SEL	15-150	2, 3

GE Series Rating Chart

Note: The following circuit breakers may be substituted for the circuit breakers shown in the series rating tabulations. Devices with MicroVersaTrip Plus and PM trip units may also be substituted, provided the short circuit rating is equal to or greater than series connected rating. Ref. GE publication DET-008A.

Breaker	Substitute Breaker(s)
THQL	THQB, THQC, THQE, THHQL, THHQB, THHQC
THHQL	THHQB, THHQC
THQL-GF	THQB-GF, THQC-GF
TED	THED
SED	SEH, SEL, SEP
SEH	SEL, SEP
SEL	SEP
TQD	THQD
TFJ	TFK, THFK
SFH	SFL, SFP
SFL	SFP
TJJ	TJK, THJK, TJ4V, THJ4V, THJ9V, TJH
THJK	THJ4V, THJ9V, TJH, TJL
SGD	SGH, SGL, SGP
SGH	SGL, SGP
SGL	SGP
SKH	SKL, SKP
SKL	SKP
TPV	SS, SH, TP, TC, TCV, THP, THC, THCV
THPV	SH, THP, THC, THCV

NOTE 1: The data in these charts was compiled from information in GE Electrical Distribution & Control publication, catalog reference number GEP-1100P and GE Electrical Distribution & Control publication - UL Component Recognized Series Ratings, publication reference number DET-008A. Cooper Bussmann assumes no responsibility for the accuracy or reliability of the information. The information contained in the tables may change without notice due to equipment design modifications.

NOTE 2: The line-side fused switch may be in a separate enclosure or in the same enclosure as the load-side circuit breaker. A line-side fused switch may be integral or remote.

NOTE 3: Max fuse current rating denotes the largest amperage fuse that may be used for that series rated combination. A lower amperage fuse may be substituted for the listed fuse.

Series Connected Short Circuit Ratings

The term "Series Connected Short Circuit Rating" refers to the application of series circuit breakers in a combination that allows downstream breakers to have lower individual interrupting ratings than the available fault current.

This is permitted as long as the series combination has been tested and certified by UL.

The tables on these pages list specific main and branch breaker combinations that may be used for the short circuit interrupting ratings shown.

No substitutions are permitted. All combinations shown have been tested and are UL Listed. This information is provided as a reference tool only. **For verification of specific combination ratings consult the UL Recognized Components Directory**.

240V Series Ratings

UL Series Connected Rating	Main Breaker		Branch Breaker		
	Type	Maximum Amperes	Type	Number of Poles	Amperes
22,000	QPH, BQH, BLH	70 (1P) 125 (2P) 100 (3P)	QP, BQ, BL	1 2 3	15–70 15–125 15–100
			QE, BLE, QPF, BLF	2	15–60
			QE, BLE, BE, QPF, BQF, BLF	1	15–30
			QT	1, 2	15–40
			QG, BG	1, 2	15–30
	QPPH	225 (2P)	QP, BQ, BL	1 2	15–70 15–125
			QE, BLE, BE, QPF, BQF, BLF	1	15–30
			QE, BLE, BE, QPF, BLF	2	15–60
			QPP	2	125–200
			QT	1, 2	15–40
	QPMH	200 (2P)	QP	1	15–25 35–70
				2	15–25 35–125
			QE, QPF	1 2	15–30 15–60
			QT	2	15–30
	QJH2	225 (2 & 3P)	QP, BQ, BL	1 2 3	15–70 15–125 60–100
			QPF, BQF, BLF, QE, BE, BLE	1	15–30
			QPF, BLF, QE, BE, BLE	2	15–60
			QT	1, 2	15, 20, 40
42,000	QJ2H	225 (2 & 3P)	QP, BQ, BL	1 2 3	15–70 15–125 60–100
			QPH, BQH, BLH	1 2 3	15–70 15–125 60–100
			QJH2	2, 3	60–225
65,000	HQP, HBQ, HBL	70 (1P) 125 (2P) 100 (3P)	QP, BQ, BL, QPH, BQH, BLH	1 2 3	15–70 15–125 15–100
			QPF, BQF, BLF, BE, QPHF, BQHF, BLHF, QEH, BLEH, QE, BLE	1	15–30
			QEH, BLEH, QE, QPHF, BLHF, BLE, QPF, BLF	2	15–60
			QT	1, 2	15–40
			QG, BG	1, 2	15–30
	HQPP	225 (2P)	QP, BQ, BL, QPH, BQH, BLH	1 2	15–70 15–125
			QPF, BQF, BLF, QPHF, BQHF, BLHF, QEH, BLEH, QE, BLE, BE	1	15–30

240V Series Ratings (Continued)

UL Series Connected Rating	Main Breaker		Branch Breaker		
	Type	Maximum Amperes	Type	Number of Poles	Amperes
65,000 (Continued)			QEH, BLEH, QE, QPHF, BLHF, BLE, QPF, BLF	2	15–60
			QT	1, 2	15–40
			QPPH, QPP	2	125–200
	ED4, ED6	100 (1P) 125 (2 & 3P)	QP, BQ, BL, QPH, BQH, BLH	1 2 3	15–70 15–125 15–100
			QPHF, BQHF, BLHF, QPF, BQF, BLF, QE, QEH, BLEH, BE, BLE	1	15–30
			QEH, BLEH, QE, QPHF, BLHF, BLE, QPF, BLF	2	15–60
			ED2	1, 2, 3	15–100
			QT	1, 2	15–40
	FD6-A, FXD6-A	250 (2 & 3P)	QP, BQ, BL, QPH, BQH, BLH	1 2 3	15–70 15–125 15–100
			QJ2H, QJ2, QJH2	2, 3	60–225
			QPPH	2	125–225
	JXD2-A, JD6-A, JXD6-A, LD6-A, LXD6-A	600 (2 & 3P)	QPH, BQH, BLH	1 2 3	15–70 15–125 15–100
			QJ2H, QJH2	2, 3	60–225
	HJD6-A, HJXD6-A HLD6-A, HLXD6-A HMD6, HMXD6 HND6, HNXD6 HPD6, HPXD6 HRD6, HRXD6	2000 (2 & 3P)	QPH	1 2 3	15–70 15–125 15–100
	SJD6-A, SLD6-A, SMD6, SND6, SPD6	1600 (2 & 3P)	QPH, BQH, BLH	1 2 3	15–70 15–125 15–100
	MD6, MXD6 ND6, NXD6 PD6, PXD6 RD6, RXD6	2000 (2 & 3P)	QPH, BQH, BLH	1 2 3	15–70 15–125 15–100
100,000	HED4, HED6	125 (2 & 3P)	QP, BQ, BL, QPH, BQH, BLH, HQP, HBQ, HBL	1 2 3	15–70 15–125 15–100
			QEH, BLEH, QE, BE, QPHF, BQHF, BLHF, QPF, BLF, BQF, BLE	1	15–30
			QEH, BLEH, QPHF, BLHF, QPF, BLF, QE, BLE	2	15–60
			ED2	1, 2, 3	15–100
			ED4	1	15–100
			ED4, ED6	2, 3	15–125
			QT	1, 2	15–40
	HED4	100 (1P)	ED2, ED4	1	15–100

Series Connected Short Circuit Ratings

240V Series Ratings (Continued)

UL Series Connected Rating	Main Breaker		Branch Breaker		
	Type	Maximum Amperes	Type	Number of Poles	Amperes
100,000 (Continued)	HQPPH	225 (2P)	QP, BQ, BL, QPH, BQH, BLH, HQP, HBQ, HBL	1 2	15–70 15–125
			HQPP, QPPH, QPP	2	125–225
			QEH, BLEH, QE, BE, QPHF, BQHF, BLHF, QPF, BQF, BLF, BLE	1	15–30
			QE, QEH, BLEH, QPHF, BLHF, QPF, BLF, BLE	2	15–60
			QT	1, 2	15–40
	HQJ2H	225 (2 & 3P)	QP, BQ, BL	1	15–25 35–70
				2	15–25 35–125
				3	15–100
			QPH, BQH, BLH, HQP, HBQ, HBL	1 2 3	15–70 15–125 15–100
			QEH, BLEH, QE, BE, QPHF, BQHF, BLHF, QPF, BQF, BLF, BLE	1	15–30
			QEH, BLEH, QPHF, BLHF, QE, BLE, QPF, BLF	2	15–60
			QT	1	15–50
	HFD6, HFXD6	250 (2 & 3P)	QP, BQ, BL, QPH, BQH, BLH, HQP, HBQ, HBL	1 2 3	15–70 15–125 15–100
			QE, BE, BLE, QPHF, BQHF, BLHF, QPF, BQF, BLF QEH, BLEH	1	15–30
			QPF, BLF, QE, BLE, QPHF, BLHF, QEH, BLEH	2	15–60
			ED4	1	15–100
			ED4, ED6	2, 3	15–125
			FD6-A, FXD6-A	2, 3	70–250
			QJ2, QJH2, QJ2H	2, 3	60–225
			HQPP, QPPH, QPP	2	125–225
			QT	1, 2	15–40
	HJD6-A, HJXD6-A, SHJD6-A	400 (2 & 3P)	ED4	1	15–100
			ED4, ED6	2, 3	15–125
			FD6-A, FXD6-A	2, 3	70–250
			JD6-A, JXD6-A, JXD2-A, SJD6-A	2, 3	200–400
	HLD6-A	600 (2 & 3P)	ED4	1	15–100
			ED4, ED6	2, 3	15–125
			FD6-A, FXD6-A	2, 3	70–250
			JD6-A, JXD6-A, JXD2-A, SJD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
			SLD6-A	3	300–600

240V Series Ratings (Continued)

UL Series Connected Rating	Main Breaker		Branch Breaker		
	Type	Maximum Amperes	Type	of Poles	Number Amperes
100,000 (Continued)	HLXD6-A	600 (2 & 3P)	ED4	1	15–100
			ED4, ED6	2, 3	15–125
			FD6-A FXD6-A	2, 3	70–250
			JD6-A, JXD6-A, JXD2-A, SJD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
			SLD6-A	3	300–600
	SHLD6-A	600 (3P)	ED4	1	15–100
			ED4, ED6	2,3	15–125
			FD6-A, FXD6-A	2, 3	70–250
			JD6-A, JXD6-A, JXD2-A, SJD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
			SLD6-A	3	300–600
	HMD6,HMXD6	800 (2 & 3P)	ED4	1	15–100
			ED4, ED6	2, 3	15–125
			FD6-A, FXD6-A	2, 3	70–250
			JD6-A, JXD6-A, JXD2-A, SJD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
			SLD6-A	3	300–600
			MD6, MXD6 SMD6	2,3	500–800
	SHMD6	800 (3P)	ED4	1	15–100
			ED4, ED6	2, 3	15–125
			FD6-A, FXD6-A	2, 3	70–250
			JD6-A, JXD6-A, JXD2-A, SJD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
			SLD6-A	3	300–600
			MD6, MXD6, SMD6	2, 3	500–800
	HND6, HNXD6, SHND6	1200 (2 & 3P)	ED4	1	15–100
			ED4, ED6	2, 3	15–125
			FD6-A, FXD6-A	2, 3	70–250
			JD6-A, JXD6-A, JXD2-A, SJD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
			SLD6-A	3	300–600
			MD6, MXD6, SMD6	2, 3	500–800
			ND6, NXD6, SND6	2, 3	500–1200
	HPD6, HPXD6, SHPD	1600 (3P)	ED4	1	15–100
			ED4, ED6	2, 3	15–125
			FD6-A, FXD6-A	2, 3	70–250
			JD6-A, JXD6-A, JXD2-A, SJD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
			SLD6-A	3	300–600
			MD6, MXD6, SMD6	2, 3	500–800
			ND6, NXD6, SND6	2, 3	500–1200
			PD6, PXD6, SPD6	2, 3	1200–1600

Series Connected Short Circuit Ratings

240V Series Ratings (Continued)

UL Series Connected Rating	Main Breaker		Branch Breaker		
	Type	Maximum Amperes	Type	P	Amperes
100,000 (Continued)	HRD6, HRXD6	2000 (3P)	ED4	1	15–100
			ED4, ED6	2, 3	15–125
			FD6-A, FXD6-A	2, 3	70–250
			JD6-A, JXD6-A, JXD2-A, SJD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
			SLD6-A	3	300–600
			MD6, MXD6, SMD6	2, 3	500–800
			ND6, NXD6, SND6	2, 3	500–1200
			PD6, PXD6, SPD6	2, 3	1200–1600
			RD6, RXD6	2, 3	1600–2000
200,000	CED6	125 (2 & 3P)	QP, BQ, BL, QPH, BQH, BLH, HQP, HBQ, HBL	1 2 3	15–70 15–125 15–100
			QPHF, BQHF, BLHF, QPF, BQF, BLF, QEH, QE, BE, BLE, BLEH	1	15–30
			QEH, BLEH, QPHF, BLHF, QPF, BLF, QE, BLE	2	15–60
			ED4, HED4	1	15–100
			ED4, ED6, HED4, HED6	2, 3	15–125
			QT	1, 2	15–40
	CFD6	250 (2 & 3P)	QP, BQ, BL, QPH, BQH, BLH, HQP, HBQ, HBL	1 2 3	15–70 15–125 15–100
			QPHF, BQHF, BLHF, QE, BE, BLE, QPF, BQF, BLF, QEH, BLEH	1	15–30
			QPHF, BLHF, QE, BLE, QPF, BLF, QEH, BLEH,	2	15–60
			ED2	1, 2, 3	15–100
			HED4, ED4	1	15–100
			ED4, ED6, HED4, HED6	2, 3	15–125
			FD6-A, FXD6-A, HFD6, HFXD6	2, 3	70–250
			QJ2H, QJH2, QJ2	2, 3	60–225
			QPPH, QPP	2	125–225
			QT	1, 2	15–40
	HHJD6, HHJXD6, HHLD6, HHLXD6	600 (2 & 3P)	FD6-A, FXD6-A, HFD6, HFXD6	2, 3	70–250
	CJD6	400 (2 & 3P)	QPH, BQH, BLH, HQP, HBQ, HBL	2 3	100–125 100
			ED4, ED6	2, 3	15–125
			FD6-A, FXDG-A, HFD6, HFXD6	2, 3	70–250
			JXD2-A, JD6-A, JXD6-A, HJD6-A, HJXD6-A	2, 3	200–400
			QT	1, 2	15–30

240V Series Ratings (Continued)

UL Series Connected Rating	Main Breaker		Branch Breaker		
	Type	Maximum Amperes	Type	P	Amperes
200,000	CLD6	600 (2 & 3P)	QPH, BQH, BLH, HQP, HBQ, HBL	2 3	100–125 100
			ED4, ED6	2, 3	15–25
			FD6-A, FXD6-A, HFD6, HFXD6	2, 3	70–250
			JXD2-A, JD6-A, JXD6-A, HJD6-A, HJXD6-A	2, 3	200–400
			LD6-A, HLD6-A	2, 3	200–600
			LXD6-A, HJXD6-A	2, 3	450–600
			QT	1, 2	15–30
	CMD6	800 (2 & 3P)	ED4, ED6	1	15
			ED4, ED6, HED4, HED6	2, 3	15–125
			FD6-A, FXD6-A, HFD6, HFXD6	2, 3	70–250
			JXD2-A, JD6-A, JXD6-A, HJD6-A, HJXD6-A	2, 3	200–400
			LD6-A, HLD6-A	2, 3	200–600
			LXD6-A, HLXD6-A	2, 3	450–600
			MD6, MXD6, HMD6, HMXD6	2, 3	500–800
	SCMD6	800 (3P)	MD6, MXD6, HMD6, HMXD6	2, 3	500–800
	CND6	1200 (2 & 3P)	ED4, ED6	1	15
			ED4, ED6, HED4, HED6	2, 3	15–125
			FD6-A, FXD6-A, HFD6, HFXD6	2, 3	70–250
			JXD2-A, JD6-A, JXD6-A, HJD6-A, HJXD6-A	2, 3	200–400
			LD6-A, HLD6-A	2, 3	200–600
			LXD6-A, HLXD6-A	2, 3	450–600
			MD6, MXD6, HMD6, HMXD6	2, 3	500–800
			ND6, NXD6, SND6, HND6, HNXD6	2, 3	500–1200
	SCND6	1200 (3P)	MD6, HMD6, HMXD6, MXD6, SHMD6, SMD6	2, 3	500–800
			ND6, HND6, SHND6, NXD6, HNXD6, SND6	2, 3	500–1200
	CPD6	1600 (3P)	FD6-A, FXD6-A, HFD6, HFXD6	2, 3	70–250
			JXD2-A, JD6-A, JXD6-A, HJD6-A, HJXD6-A	2, 3	200–400
			LD6-A, HLD6-A	2, 3	200–600
			LXD6-A, HLXD6-A	2, 3	450–600
			MD6, MXD6, HMD6, HMXD6	2, 3	500–800
			ND6, NXD6, SND6, HND6, HNXD6	2, 3	500–1200

Series Connected Short Circuit Ratings

480V Series Ratings

UL Series Connected Rating	Main Breaker		Branch Breaker		
	Type	Maximum Amperes	Type	of Poles	Number Amperes
18,000	ED4	125 (2 & 3P)	BQD, CQD	1, 2, 3	15–100
25,000	ED6	125 (2 & 3P)	BQD, CQD	1, 2, 3	15–100
30,000	HED6	125 (2 & 3P)	BQD, CQD	1, 2, 3	15–100
			ED4	1	15–100
			ED4, ED6	2, 3	15–125
42,000	HED4	125 (2 & 3P)	BQD, CQD	1, 2, 3	15–100
			ED4	1	15–100
			ED4, ED6	2, 3	15–125
50,000	HJD6-A, HJXD6-A, HLD6-A, HLXD6-A	600 (2 & 3P)	HED4	2, 3	15–50
	MD6, MXD6, ND6, NXD6	1200 (2 & 3P)	FD6-A, FXD6-A	2, 3	70–250
			JD6-A, JXD6-A, SJD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
			SLD6-A	3	400–600
	SMD6, SND6, SPD6	1600 (3P)	JD6-A, JXD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
			SLD6-A	3	400–600
	PD6, PXD6	14–1600 (3P)	FD6-A, FXD6-A	2, 3	70–250
		1600 (3P)	JD6-A, JXD6-A, SJD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
			SLD6-A	3	400–600
	RD6, RXD6	18–2000 (3P)	FD6-A, FXD6-A	2, 3	70–250
			JD6-A, JXD6-A, SJD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
			SLD6-A	3	400–600
65,000	HFD6, HFXD6	250 (2 & 3P)	BQD, CQD	1, 2, 3	15–100
			ED4, HED4	1	15–100
			ED4, ED6, HED4, HED6	2, 3	15–125
	HJD6-A, HJXD6-A	400 (2 & 3P)	HED4, ED4	1	15–100
			FD6-A, FXD6-A	2, 3	70–250
			JD6-A, JXD6-A	2, 3	200–400
	HLD6-A, HLXD6-A	600 (2 & 3P)	ED4, HED4	1	15–100
			FD6-A, FXD6-A	2, 3	70–250
			JD6-A, JXD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
	HMD6, HMXD6	800 (2 & 3P)	FD6-A, FXD6-A	2, 3	70–250
			JD6-A, JXD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
	HND6, HNXD6	1200 (2 & 3P)	FD6-A, FXD6-A	2, 3	70–250
			JD6-A, JXD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
			MD6, MXD6, SMD6	2, 3	500–800
	HPD6, HPXD6	14–1600 (3P)	FD6-A, FXD6-A	2, 3	70–250

480V Series Ratings (Continued)

UL Series Connected Rating	Main Breaker		Branch Breaker		
	Type	Maximum Amperes	Type	Number of Poles	Amperes
65,000 (Continued)	HRD6, HRXD6	18–2000 (3P)	FD6-A, FXD6-A	2, 3	70–250
			JD6-A, JXD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
100,000	CFD6	250 (2 & 3P)	BQD, CQD①	1 2, 3	15–100 15–30
	HHJXD6, HHJD6, HHLD6, HHLXD6	600 (2 & 3P)	ED4, ED6, HED4, HED6	1	15–100
			HFD6, HFXD6	2, 3	70–250
	CMD6	800 (3P)	FD6-A, FXD6-A, HFD6, HFXD6	2, 3	70–250
			JD6-A, HJD6-A, JXD6-A, HJXD6-A	2, 3	200–400
			LD6-A, HLD6-A	2, 3	200–600
			LXD6-A, HLXD6-A	2, 3	450–600
			MD6, MXD6, HMD6, HMXD6	2, 3	500–800
	SCMD, SCND6	1200 (3P)	HFD6, HFXD6	2, 3	70–250
	CND6	1200 (3P)	FD6-A, FXD6-A, HFD6, HFXD6	2, 3	70–250
			JD6-A, HJD6-A, JXD6-A, HJXD6-A	2, 3	200–400
			LD6-A, HLD6-A	2, 3	200–600
			LXD6-A, HLXD6-A	2, 3	450–600
			MD6, MXD6, HMD6, HMXD6	2, 3	500–800
			ND6, NXD6, HND6, HNXD6	2, 3	500–1200
	CPD6	1600 (3P)	FD6-A, FXD6-A, HFD6, HFXD6	2, 3	70–250
150,000	CJD6	400 (2 & 3P)	ED4	1	15–100
			HFD6, HFXD6	2, 3	70–250
			JD6-A, HJD6-A, JXD6-A, HJXD6-A	2, 3	200–400
	CLD6	600 (2 & 3P)	ED4	1	15–100
			HFD6, HFXD6	2, 3	70–250
			JD6-A, HJD6-A, JXD6-A, HJXD6-A	2, 3	200–400
			LD6-A, HLD6-A	2, 3	200–600
			LXD6-A, HLXD6-A	2, 3	450–600
200,000	CED6	125 (2 & 3P)	BQD, CQD①	1 2, 3	15–100 20–30
			ED4, HED4	1	15–100
			ED4, ED6, HED4, HED6	2, 3	15–125
	CFD6	250 (2 & 3P)	BQD, CQD	1 2, 3	15–100 20–30
			ED4, ED6	2,3	15–50
			ED4, HED4	1	15–100
			HED4, HED6	2, 3	15–125
			FD6-A, FXD6-A, HFD6, HFXD6	2, 3	70–250

① BQD & CQD breakers (2, 3P) are series rated from 15–100A for Series 7A, S2 and S3 panelboard applications only.

Series Connected Short Circuit Ratings

240 Volt Fuse Series Ratings

UL Series Connected Rating	Main Breaker		Branch Breaker		
	Type	Maximum Amperes	Type	Number of Poles	Amperes
65,000	J, R	15–600 (1, 2, 3P)	QPH, BQH, BLH	1, 2, 3	15–125
	T	15–1200 (1, 2, 3P)	QPH, BQH, BLH	1, 2, 3	15–125
	L	601–6000 (1, 2, 3P)	QPH, BQH, BLH	1, 2, 3	15–125
100,000	T (300V)	15–200 (1, 2, 3P)	QP, BQ, BL	1, 2, 3	15–125
			HQP, HBQ, HBL, QPH, BQH, BLH	3	15–100
			QPF, BQF, BLF, QE, BE, BLE, QEH, BLEH, BLHF, QPHF, BQHF	1	15–30
			QEH, BLEH, QE, QPHF, BLHF, BLE, QPF, BLF	2	15–60
			QT	1, 2	15–50
		15–600 (1, 2, 3P)	QPH, BQH, BLH, HQP, HBQ, HBL	1, 2	15–125
	J, R	15–600 (2, 3P)	ED4, HED4	1	15–100
			ED4, ED6, HED4, HED6	2, 3	15–125
		70–600 (2, 3P)	FD6-A, FXD6-A	2, 3	70–250
		200–600 (2, 3P)	JD6-A, JXD6-A, JXD2-A, SJD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
		300–600 (3P)	SLD6-A	3	300–600
		450–600 (2, 3P)	LXD6-A	2, 3	450–600
	T	15–1200 (2, 3P)	ED4, HED4	1	15–100
			ED4, ED6, HED4, HED6	2, 3	15–125
		70–1200 (2, 3P)	FXD6-A, FD6-A	2, 3	70–250
		450–1200 (2, 3P)	LXD6-A	2, 3	450–600
		200–1200 (2, 3P)	JD6-A, JXD6-A, JXD2-A, SJD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
		300–1200 (3P)	SLD6-A	3	300–600
	L	601–6000 (2, 3P)	ED4, HED4	1	15–100
			ED4, ED6, HED4, HED6	2, 3	15–125
			FD6-A, FXD6-A	2, 3	70–250
			JD6-A, JXD6-A, JXD2-A, SJD6-A	2, 3	200–400
			LD6-A	2, 3	200–600
			LXD6-A	2, 3	450–600
			SLD6-A	3	300–600
			SMD6	3	500–800
			SND6	3	500–1200
			PD6, PXD6, SPD6	3	1200–1600
			RD6, RXD6	3	1600–2000
200,000	R	125–200 (2, 3P)	QJH2, QJ2H, QJ2	2, 3	125–200
	T, J	125–600 (2, 3P)	QJH2, QJ2H	2, 3	125–225
		125–400 (2, 3P)	QJ2	2, 3	125–225
	J, R	70–600 (2, 3P)	HFD6, HFXD6	2, 3	70–250

240 Volt Series Ratings (Continued)

UL Series Connected Rating	Main Breaker		Branch Breaker		
	Type	Maximum Amperes	Type	Number of Poles	Amperes
200,000	T	70–1200 (2, 3P)	HFD6, HFXD6	2, 3	70–250
	L	601–6000 (2, 3P)	HFD6, HFXD6	2, 3	70–250
			MD6, MXD6, HMD6, HMXD6	2, 3	500–800
			ND6, NXD6, HND6, HNXD6	2, 3	500–1200

480 Volt Fuse Series Ratings

UL Series Connected Rating	Main Breaker		Branch Breaker		
	Type	Maximum Amperes	Type	Number of Poles	Amperes
50,000	J	60–400 (1, 2, 3P)	ED4	1	60–100
		15–400 (2, 3P)	ED4	2, 3	15–100
100,000	J	15–400 (1, 2, 3P)	ED4	1	15–50
	T, J	70–600 (2, 3P)	FD6-A, FXD6-A	2, 3	70–250
	J, R	70–600 (2, 3P)	HFD6, HFXD6	2, 3	70–250
	T, J, R	200–600 (2, 3P)	JD6-A, JXD6-A HJD6-A, HJXD6-A	2, 3	200–400
			LD6-A, HLD6-A	2, 3	200–600
		450–600 (2, 3P)	LXD6-A, HLXD6-A	2, 3	450–600
	T	70–1200 (2, 3P)	HFD6, HFXD6	2, 3	70–250
	T, L	601–1200 (2, 3P)	JD6-A, JXD6-A HJD6-A, HJXD6-A	2, 3	200–400
			LD6-A, HLD6-A	2, 3	200–600
			LXD6-A, HLXD6-A	2, 3	450–600
	L	601–6000 (2, 3P)	HFD6, HFXD6	2, 3	70–250
			MD6, MXD6, HMD6, HMXD6	2, 3	500–800
			ND6, NXD6, HND6, HNXD6	2, 3	500–1200
200,000	R	15–100 (1, 2, 3P)	BQD, CQD	1	15–100
			BQD, CQD①	2, 3	20–30
	T, J	15–200 (1, 2, 3P)	BQD, CQD	1	15–100
			BQD, CQD①	2, 3	20–30

① BQD & CQD breakers are series rated from 15–100A for Series 7A, S2 and S3 panelboard applications only.

Siemens Series Rating Chart

Switchboards SB1, SB2, SB3
Panelboard S1

(See Notes on Page 2)

Max System Voltage	Maximum SCCR	Line Side Fuse	Max Fuse Current Rating	Load side		
				Circuit Breaker	Amps	Poles
120/240 Vac	65kA	LPJ, LPN-RK	600	QPH, BQH, BLH	15-70	1 (120V)
		JJN (300V)	1200		15-125	2
		KRP-C	6000		15-100	3
	100kA	JJN (300V)	200	QP, BQ, BL	15-70	1 (120V)
					15-125	2
					15-100	3
				HQP, HBQ, HBL, QPH, BQH, BLH	15-100	3
				QPF, BQF, BLF, QE, BE, BLE, QEH, BLEH, BLHF, QPHF, BQHF	15-30	1 (120V)
				QEH, BLEH, QE, QPHF, BLHF, BLE, QPF, BLF	15-60	2
				QT	15-50	1 (120V),2
			600	QPH, BQH, BLH, HQP, HBQ, HBL	15-70	1 (120V)
					15-125	2
					15-100	3
240 Vac	100kA	LPJ, LPN-RK	600	ED4, HED4	15-100	1 (120V)
				ED4, ED6, HED4, HED6	15-125	2,3
				FD6-A, FXD6-A	70-250	2,3
				JD6-A, JXD6-A, JXD2-A, SJD6-A	200-400	2,3
				LD6-A	200-600	2,3
				SLD6-A	300-600	3
				LXD6-A	450-600	2,3
		JJN (300V)	1200	ED4, HED4	15-100	1 (120V)
				ED4, ED6, HED4, HED6	15-125	2,3
				FD6-A, FXD6-A	70-250	2,3
				JD6-A, JXD6-A, JXD2-A, SJD6-A	200-400	2,3
				LD6-A	200-600	2,3
				SLD6-A	300-600	3
				LXD6-A	450-600	2,3
		KRP-C	6000	ED4, HED4	15-100	1 (120V)
				ED4, ED6, HED4, HED6	15-125	2,3
				FD6-A, FXD6-A	70-250	2,3
				JD6-A, JXD6-A, JXD2-A, SJD6-A	200-400	2,3
				LD6-A	200-600	2,3
				SLD6-A	300-600	3
				LXD6-A	450-600	2,3
				SMD6	500-800	3
				SND6	500-1200	3
				PD6, PXD6, SPD6	1200-1600	3
				RD6, RXD6	1600-2000	3
	200kA	LPN-RK	200	QJH2, QJ2H, QJ2	125-200	2,3
		JJN (300V)	400	QJ2	125-225	2,3
		LPJ	600	QJH2, QJ2H	125-225	2,3
		LPJ, LPN-RK	600	HFD6, HFXD6	70-250	2,3
		JJN (300V)	1200	HFD6, HFXD6	70-250	2,3
		KRP-C	6000	HFD6, HFXD6	70-250	2,3
				MD6, MXD6, HMD6, HMXD6	500-800	2,3
				ND6, NXD6, HND6, HNXD6	500-1200	2,3

Siemens Series Rating Chart

Switchboards SB1, SB2, SB3
Panelboards S2, SE, S3, S4, S5

(See Notes Below)

Max System Voltage	Maximum SCCR	Line Side Fuse	Max Fuse Current Rating	Load side		
				Circuit Breaker	Amps	Poles
480 Vac	50kA	LPJ	400	ED4	60-100	1 (277V)
					15-100	2,3
	100kA	LPJ	400	ED4	15-50	1 (277V)
		JJS, LPJ	600	FD6-A, FXD6-A	70-250	2,3
		LPJ, LPS-RK	600	HFD6, HFXD6	70-250	2,3
		JJS, LPJ, LPS-RK	600	JD6-A, JXD6-A, HJD6-A, HJXD6-A	200-400	2,3
				LD6-A, HLD6-A	200-600	2,3
				LXD6-A, HLXD6-A	450-600	2,3
		JJS	800	HFD6, HFXD6	70-250	2,3
		JJS, KRP-C	1200	JD6-A, JXD6-A, HJD6-A, HJXD6-A	200-400	2,3
				LD6-A, HLD6-A	200-600	2,3
				LXD6-A, HLXD6-A	450-600	2,3
		KRP-C	6000	HFD6, HFXD6	70-250	2,3
				MD6, MXD6, HMD6, HMXD6	500-800	2,3
				ND6, NXD6, HND6, HNXD6	500-1200	2,3
480/277V	200kA	LPS-RK	100	BQD, CQD	15-100	1 (277V)
				BQD*, CQD *	20-30	2,3
		JJS, LPJ	200	BQD, CQD	15-100	1 (277V)
				BQD*, CQD *	20-30	2,3

* BQD and CQD breakers are series rated from 15-100A for Series 7A, S2 and S3 panelboard applications only.

NOTE (1): The data in these charts was compiled from information in Siemens SpeedFax 2000 Electrical Products publication, catalog reference number GNPC-01000. Cooper Bussmann assumes no responsibility for the accuracy or reliability of the information. The information contained in the tables may change without notice due to equipment design modifications.

NOTE (2): The line-side fused switch may be in a separate enclosure or in the same enclosure as the load-side circuit breaker. A line-side fused switch may be integral or remote.

NOTE (3): Max fuse current rating denotes the largest amperage fuse that may be used for that series rated combination. A lower amperage fuse may be substituted for the listed fuse.