Applying Short Circuit Current and Series Connected Ratings
Class 600

Short-Circuit Current Ratings

Article 110.9 of the National Electrical Code (NEC® 2011) states that "There are instances where total coordination and a series rating can be achieved with specific pairs of circuit breakers." With the recent trend toward increased system fault capacity, it is important to know what equipment can be safely applied on systems with high available fault currents. The most common method accepted for documenting these maximum ratings is listing each product with Underwriters Laboratories® (UL®) or the Canadian Standards Association (CSA).

Short circuit current ratings (SCCR) are used to select end-use equipment for specific available fault current applications. This maximum current rating applies only to end-use equipment such as switchboards, panelboards, and motor control centers. The equipment may or may not include overcurrent devices that have UL Listed series-connected ratings. The UL Listed short-circuit current rating covers not only the overcurrent protective devices in the end-use equipment, but also the overall construction of that equipment (i.e., busbars, bus bracing, enclosure, etc.).

What are Series-Connected Ratings?

The term series-connected rating applies to combinations of overcurrent protective devices which are electrically connected in series, using a remote or integral main. Each specific circuit breaker/circuit breaker or fuse/circuit breaker combination must meet UL requirements, including UL witnessed test procedures as defined in UL Standard 489 "Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures." These test procedures include three test sequences:

- Standard UL tests for the individual component (circuit breaker or fuse)
- Series-connected tests
- Series-connected tests in end-use equipment

It is important to understand that series-connected ratings are not short circuit current ratings until the overcurrent devices are installed and tested in end-use equipment and the equipment is appropriately labeled.

UL Testing Series-Connected Ratings

UL Recognized series-connected ratings are tested in accordance with UL 489, which requires that the line side (main) device must have an ampere interrupting rating (AIR) as great as or greater than the series-connected rating claimed. The load side (branch) circuit breaker may have a lower interrupting rating. Each device must be mounted and tested in the smallest enclosure with which it is intended to be used, or in the appropriate end-use equipment.

After the series combination safely interrupts the short circuit test currents, the circuit breakers must successfully pass both a trip-out and dielectric voltage withstand test, all of which are witnessed by UL engineers. UL Standard 489 clearly defines all parameters for both submittal and follow-up testing of series combinations. (All manufacturer's UL tested and recognized ratings have been tested to the same standard and may be compared.) Once a series rating is achieved, the manufacturer's name and

Type/catalog numbers for main and branch devices may be published in the UL Recognized Component Directory. Another source of information for series-connected ratings is published literature from the manufacturer.

Underwriters Laboratories also allows series ratings between different manufacturer's products. An example of this is fuse/circuit breaker series-connected ratings. Because of the manufacturing deviations, all fuses of the same class produced by different manufacturers do not have the same interrupting or let-through characteristics. For this reason a special fuse is required for the UL tests to provide an envelope (or umbrella) main, which is designed as a "worst case" fuse. Using this method, a main fuse is denoted by fuse class (not UL type) or catalog number, thus any manufacturer's fuse may be used in the series-connected rating. If the series-connected ratings is between different manufacturer's circuit breakers, then each specific manufacturer's name or Type/catalog number must be listed and appropriately marked in the end-use equipment. Little mixing of circuit breaker manufacturers is being done today.

Follow-Up Testing

Every two or three years, depending on the circuit breaker ampere rating, the series-connected rating is retested in the smallest enclosure with which is it intended to be used and witnessed by UL personnel to assure its validity.

Affect of Series-Connected Ratings on Coordination

Coordination is the process of localizing a fault condition to restrict outages to the equipment affected, accomplished by choosing selective fault protection devices. This is also referred to as selectivity. In other words, only the device closest to the fault should open or trip, leaving the rest of the system intact to supply power to the unaffected areas.

As a result of the potential simultaneous opening, some designers of electrical distribution systems believe that all circuit breaker coordination is lost when using series-connected ratings. In reality, using series-connected ratings provides virtually the same system coordination as a fully-rated system.

Figure 1: System Coordination

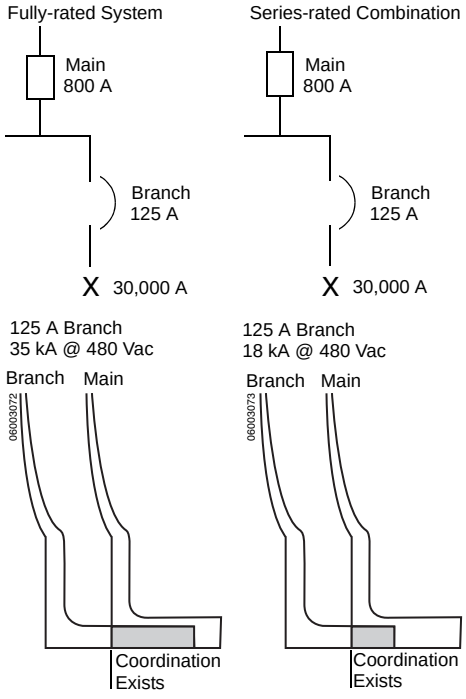

Figure 1 compares system coordination for both fully-rated and series-rated combinations of molded case circuit breakers. The system voltage is 480 Vac, with available fault current of 30,000 amperes.

In both the fully-rated and series-rated combinations, coordination exists for all values of current below the magnetic instantaneous pickup point of the main circuit breaker.

For current levels above the magnetic pickup point of the main circuit breaker, simultaneous opening of the main and branch circuit breakers may occur.

As you can see from the time-current curves, coordination is not sacrificed when series-connected ratings are utilized.

In both the series-rated and fully-rated systems, coordination is achieved to the same degree. In fact, when a UL Recognized series-rated combination is used, the branch circuit breaker is more likely to be a smaller frame size than in the case of a fully-rated system. The smaller frame size branch circuit breaker will have a different characteristic time-current curve and may result in better overall coordination.

In both systems, the only time the two circuit breakers trip at the same time is under high fault conditions. Such high amperage faults are rare, less than 10% of all faults. When they do occur, the fact that both circuit breakers open to interrupt the fault actually helps protect the system from damage possible at high fault currents. See Data Bulletin 0100DB0501 *Short Circuit Selective Coordination for Low Voltage Circuit Breakers* for more information.

How do Series Ratings Become Short Circuit Current Ratings?

Combinations of circuit breakers or fuses which have passed the test criteria for series-connected circuit breakers in accordance with UL 489 cannot necessarily be applied in every application. Additional tests are required by UL with the overcurrent devices installed to assure the internal construction of the end-use equipment will meet the required standards for safety. These tests establish the Short Circuit Current Ratings. The standards that govern this testing are UL 67 for panelboards, UL 891 for switchboards, UL 508 for motor control centers and UL 414 for metering.

SCCR's of end-use equipment cover both series-rated and fully-rated devices in that equipment. Therefore, the short circuit current rating label on the end-use equipment denotes the specific overcurrent protective devices that may be used at the designated short circuit levels. A UL Recognized series-rated combination does not meet UL requirements unless the end use equipment is labeled for that specific series-rated combination for overcurrent devices.

Engineered Series Ratings

Section 240.86(A) in the NEC allows for series ratings to be calculated by a licensed professional engineer. It is of utmost importance to note this requirement in the section:

> For calculated applications, the engineer shall ensure that the downstream circuit breaker(s) that are part of the series combination remain passive during the interruption period of the line side fully rated, current-limiting device.

Advantages of Utilizing Series-Connected Ratings

There are three primary advantages of using short-circuit current ratings which utilize series-connected ratings:

- less design time
- smaller equipment sizes
- reduced equipment costs.

Less Design Time

When selecting series-rated overcurrent protective devices for a distribution system, it is not necessary to calculate the maximum short circuit current levels available down to the line side terminal for the branch device. Once the available fault current level at the main is defined, series-rated combinations may be selected from a manufacturer's published matrix, such as the Schneider Electric Digest or product data bulletin 2700DB9901. All published combinations are UL Recognized. Using the matrix approach provides a simple but accurate method to minimize time spent selecting overcurrent protective devices.

Smaller Equipment Size

Using series-connected ratings often permits the use of lower interrupting rating branch circuit breakers. That can reduce equipment size because the downstream circuit breaker is often a smaller frame size than in a fully-rated system. The reduced circuit breaker size allows more circuit breakers per enclosure or may allow a smaller enclosure as well, saving critical space in crowded electrical service rooms.

Reduced Equipment Cost

Proper use of series-connected ratings can provide economic and protective advantages to the customer. In Figure 1, there is an available fault current of 30,000 amperes at 480 Vac. By using series-connected ratings with an 800 ampere main circuit breaker, standard (18,000 AIR) branch circuit breakers may be used.

In a fully-rated system, all circuit breakers in the switchboard must have an interrupting rating of at least 30,000 amperes, In this case, a more expensive branch circuit breaker with a higher interrupting rating (35,000 AIR) must be used with the same 800 ampere main.

Significant cost savings can be realized by using series-connected ratings with a standard branch circuit breaker rather than the higher priced, higher interrupting rating circuit breaker.

Summary:

- Short circuit current ratings (SCCR) are used for selection and application of end-use electrical equipment.
- Short circuit current ratings are UL Listed.
- The UL test program includes testing of the end-use equipment with the overcurrent protective devices installed.
- Short circuit current ratings may or may not utilize series-connected ratings.
- Series-connected ratings may apply to circuit breaker/circuit breaker or fuse/circuit breaker combination.
- Advantages of series-connected ratings include:
  - — Less design time
  - — Smaller equipment size
  - — Reduced equipment costs

Series-connected ratings can only be applied in end-use equipment when the short circuit current rating label on the end-use equipment denotes the specific series combination of over-current protective devices.

System overcurrent coordination is not sacrificed when series-connected ratings are applied.

Series rated overcurrent devices can be properly applied only as an integral part of a short-circuit current rating assigned to end-use equipment.

Reference Material

Schneider Electric Data Bulletin 2700DB9901

Schneider Electric Digest

“Series Connected Circuit Breakers, Test and Know”, by George Gregory and Wayne Stoppelmoor; *Conference Record of the 2000 IEEE-IAS/PCA Cement Industry Technical Conference*, May 2000, pp. 87-95. (Can be obtained from IEEE at ieeexplore.org)

For More Information

For more information on short-circuit current and series-connected ratings, or other topics relating to the use and application of circuit breakers, contact your local Schneider Electric field office.

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