January 17, 2025

To Samer Wehbe – Electrical Engineer Assoc.
Elect. Plan Check – Metro

RE: Valley Villas Bldg 6 Sepulveda-Plummer Ph1
9421 N Sepulveda Blvd Los Angeles CA

Series Rating Documentation

This letter is written to document the two types of series ratings used on this project, to allow L.A. D.B.S. Plan Check to verify compliance with the NEC/CEC and insure a safe, operational power distribution system on the subject project.
To describe the four levels of overcurrent devices on this distribution system, attached is a snip from the latest single line diagram on the project electrical plans.

- 600A Class T fused Main Service Disconnect – fully rated for 100kA
- Tenant meter/main breakers type QD – stand alone rating of 25kA
- Main tenant panelboard/load center type HOM breakers – stand alone rating of 10kA
- Tenant subpanel/load centers type HOM breakers – stand alone rating of 10kA

There is a 3-tier series rating documented on the revised plan drawings showing 100kA series rating using the Class T 600A main fuse, type QD tenant meter/main breaker and type HOM load center breaker.
This leaves the last and lowest level of overcurrent devices in the tenant subpanels as type HOM. The plan drawing calculations show that the highest fault current that any of the subpanels would experience is 14,912A. Since this exceeds the HOM stand alone rating of 10kA the solution is to use the 2-tier series rating with the upstream type QD tenant meter/main breaker. Although there is a HOM breaker between the QD and HOM subpanel breaker, the certified testing by UL and NEMA for series ratings allows for this combination to be recognized as a safe application. The middle breaker can either be fully rated or in this case, be part of a 3 tier series rating. This combination of 2-tier and 3-tier series ratings is documented in an example in the attached NEMA publication – please refer to page 9. Both referenced series ratings are on the revised plan drawings and highlighted.

If you have questions regarding this letter or CEC compliance, please contact me.

Thank you,

Keith Johnson, P.E.
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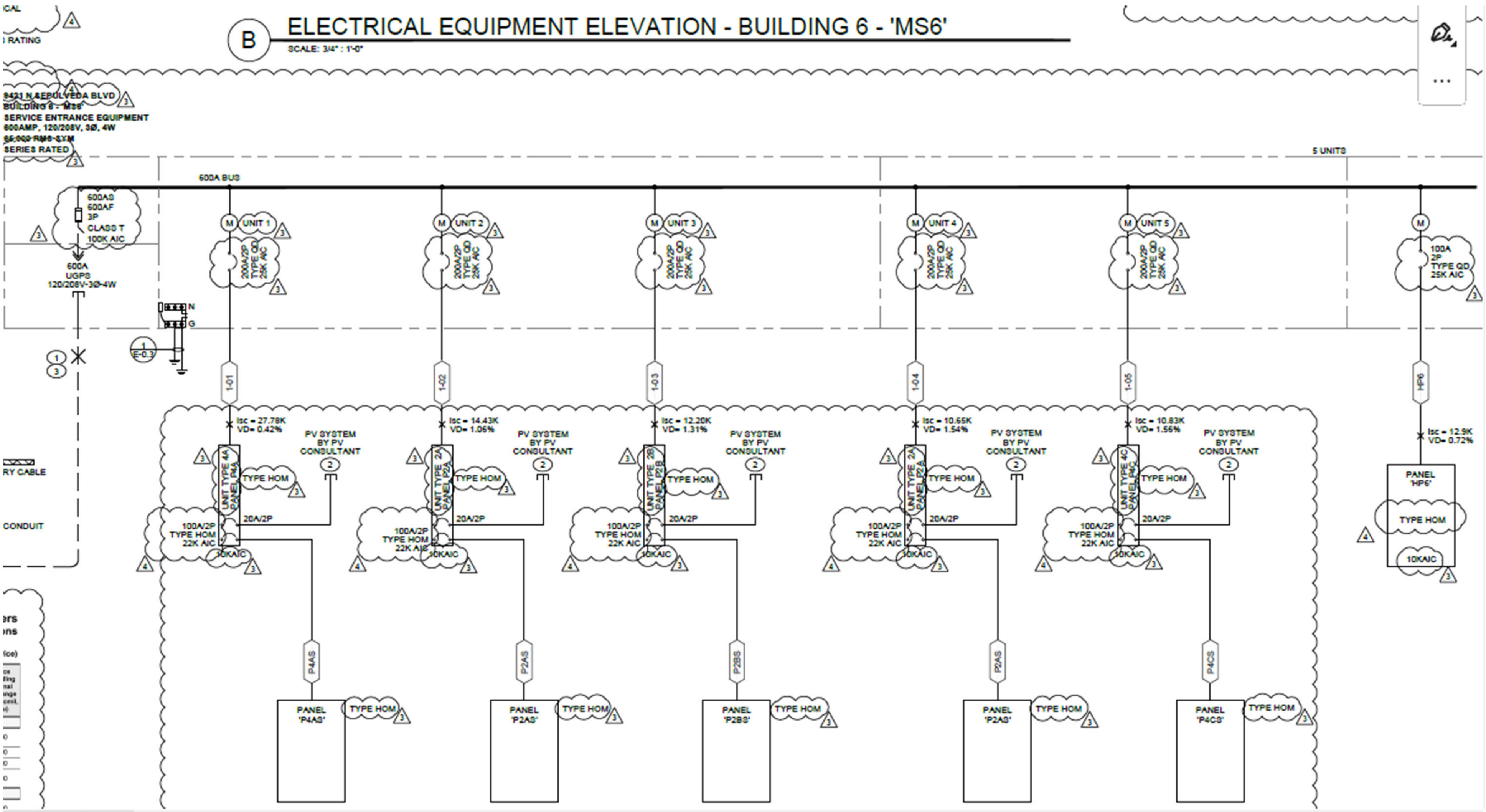
Excerpt from Electrical Plans – main system one line diagram



Excerpt from Electrical Plans – 3-tier and 2-tier Series Ratings

SERIES COMBINATION SHORT CIRCUIT CURRENT RATING / VALORES NOMINALES DE LA CORRIENTE DE CORTOCIRCUITO EN SERIE

Interrupting Rating RMS Symmetrical Amperes at ___ V~ Max. / Valor nominal de interrupción A simétricos rcm a ___ V~ máx.	Line Side SQUARE D Circuit Breaker Catalog Designation or Fuse Class / Clase de fusible o designación de catálogo de los interruptores automáticos SQUARE D del lado de línea (Max. A rating / Valor nominal máx. en A) •	Poles / Polos	SQUARE D Tenant Circuit Breaker (Integral or Remote) / Interruptor Automático del Usuario de SQUARE D (Integral o Remoto)		Integral Main Breaker / Interruptor Automático Principal Integral	QO Load Center / Centro de Carga QO — SQUARE D Circuit Breaker Catalog Designation / Designación de Catálogo de Interruptor Automático de SQUARE D •				HOMELINE Load Center / Centro de Carga HOMELINE		
			Catalog Designation (Max. A rating) / Designación de Catálogo (A Máx.) •	Poles / Polos		Branch Breaker / Interruptor Automático Derivado	Max. A Rating / Nominal A Máx. 1 Pole / 1 Polo	2 Poles / 2 Polos	3 Poles / 3 Polos	Branch Breaker / Interruptor Automatico Derivado	Max. A Rating / Nominal A Máx. 1 Pole / 1 Polo	2 Poles / 2 Polos
42,000 at 240	LA, MA	2, 3	QO-VH (125)	2	QOM1-VH or NONE	QO ¥ QOT	70 20	100		HOM § HOMT	50 30	100 50
65,000 at 240	LH, MG, MJ, MH, PG, PJ, PA (1600), RG (2000), RJ (2000)	2, 3	QO-VH (125) or QOH	2								
100,000 at 240	MHF, Class R, J, T6, T3, L (1200)	2, 3										
42,000 at 240	LA, MA	2, 3	QD (225) or QG (225)	2	QOM2-VH or NONE	QO ¥ QOT	70 20	200 ‡		HOM § HOMT	50 30	200 ‡ 50
65,000 at 240	LH, MG, MH, PG, PA (1600), RG (2000)	2, 3										
100,000 at 240, 2 pole 65,000 at 240, 3 pole 100,000 at 208Y/120, 3 pole	MJ, MHF, PJ, PH (1600), RJ (2000), Class R, J, T3, T6, L (1200)	2, 3		3		QO ¥ QO-VH QO-H	70	125 100	30 100			

• See circuit breaker for voltage and interrupting rating. / Consulte los datos del interruptor automático para obtener los valores nominales de tensión e interrupción.

See box label for additional short circuit current ratings and restrictions. / Consulte la etiqueta de la caja para obtener información adicional sobre la corriente nominal de cortocircuito y restricciones.

‡ 100 A Max. in load centers with 125 A Max. mains rating. / 100 A máx. para centros de carga con valor nominal en la linea principal de 125 A máx .

¥ QO includes suffixes AFI, EPD, EPE, GFI & PL / QO incluye los sufijos AFI, EPD, EPE, GFI y PL

§ HOM includes suffixes AFI, BB, EPD & GFI / HOM incluye los sufijos AFI, BB, EPD y GFI

SQUARE D by Schneider Electric

HRB84252

For Homeline Convertible Main Load Centers Protected with Two-Pole QD or QG Tenant Circuit Breakers

SHORT CIRCUIT CURRENT RATING / VALORES NOMINALES DE LA CORRIENTE DE CORTOCIRCUITO

Interrupting Rating RMS Symmetrical Amperes at 120/240 Vac Max. Valor nominal de interrupción A simétricos rcm, 120/240 V~ (ca) máx.	Line Side SQUARE D Circuit Breaker Catalog Designation or Fuse Class [Remote only] Clase de fusible o designación de catálogo de los interruptores automáticos SQUARE D del lado de línea [Remoto solamente] (Max. A rating / Valor nominal máx. en A)	Poles Polos	Tenant SQUARE D Circuit Breaker [Remote only] Interruptor Automático del Usuario de SQUARE D [Remoto solamente]			SQUARE D Circuit Breaker Interruptores Automáticos de SQUARE D		
			Catalog Designation Designación de Catálogo	Poles Polos	Current Rating Ampere Max. Corriente Nominal A Máx.	Catalog Designation Designación de Catálogo	Current Rating Ampere Max. Corriente Nominal A Máx. 1 Pole Polo	2 Poles Polos
10,000						HOM ¥ HOMT	50 30	125 ¶ 50
22,000	QO-VH (125)	2						
25,000	QD (225)	2						
42,000	QOH	2						
42,000	LA, MA	2, 3	QO-VH	2	125	HOM ¥ HOMT	50 30	100 ¶ 50
65,000	LH, MG, MJ, MH, PG, PJ, PA (1600), RG (2000), RJ (2000)	2, 3						
100,000	MHF, Class R, J, T6, T3, L (1200)	2, 3						
42,000	LA, MA	2, 3	QD	2	225	HOM ¥ HOMT	50 30	125 ¶ 50
65,000	QG (225)	2						
	LH, MG, MH, PG, PA (1600), RG (2000)	2, 3	QD	2	225			
100,000	QJ (225)	2						
	MJ, MHF, PJ, PH (1600), RJ (2000), Class R, J, T6, L (1200)	2, 3	QD	2	225			

The Short Circuit Current Rating is equal to the lowest interrupting rating of any circuit breaker installed or combination series connected circuit breaker. Additional or replacement circuit breaker(s) **MUST** have an interrupting rating equal to or greater than that of the circuit breaker with the lowest interrupting rating presently installed. **See panelboard wiring diagram for circuit breaker types.**

La corriente nominal de cortocircuito es igual al valor nominal de interrupción más bajo de cualquier interruptor automático instalado o combinación de interruptores automáticos conectados en serie. El interruptores automáticos adicional o de repuesto **DEBE** tener un valor nominal de interrupción igual o mayor que el del interruptor automático con el valor nominal de interrupción más bajo de cualquier interruptor automático instalado. **Vea el interior del tablero para obtener datos sobre los tipos de interruptores automáticos.**

¶ **Load centers with 100 A mains rating are limited to 100 A maximum integral main circuit breaker and 70 A maximum branch circuit breaker.**

Los centros de carga con una línea principal de 100 A nominales están limitados a 100 A como máximo para el interruptor automático principal integral y 70 A como máximo para el interruptor automático derivado.

SQUARE D by Schneider Electric

See circuit breaker for voltage and interrupting rating. Consulte los datos del interruptor automático para obtener los valores nominales de tensión e interrupción.

¥ **Catalog designation HOM includes suffixes: AFI, BB, EPD, & GFI. La designación de catálogo HOM incluye sufijos: AFI, BB, EPD, y GFI.**

40265-830-02

Applied to Fixed Main Homeline Load Centers

4

A NEMA Low Voltage Distribution Equipment Section White Paper
ABP 5-2015

Series Ratings

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Foreword

This is an update to a NEMA white paper originally published in 1994.

To ensure that a meaningful publication was being developed, draft copies were sent to a number of groups within NEMA having an interest in this topic. Their resulting comments and suggestions provided vital input prior to final NEMA approval and resulted in a number of substantive changes in this publication. This white paper will be periodically reviewed by the Molded Case Circuit Breaker Product Group of NEMA's Low Voltage Distribution Equipment Section for any revisions necessary to keep it up to date with evolving technology. Proposed or recommended revisions should be submitted to:

Vice President, Technical Services
National Electrical Manufacturers Association
1300 North 17th Street, Suite 900
Rosslyn, Virginia 22209

This white paper was developed by the Molded Case Circuit Breaker Product Group of NEMA's Low Voltage Distribution Equipment Section. Approval does not necessarily imply that all members of the Product Group voted for its approval or participated in its development. At the time this document was approved, the Molded Case Circuit Breaker Product Group had the following members:

ABB, Inc.—Wichita Falls, TX
Eaton Corporation—Pittsburgh, PA
General Electric—Plainville, CT
Siemens Industry, Inc.—Norcross, GA
Schneider Electric USA—Andover, MA

History and Definition

Series ratings first began to appear in the market around 1978. They were, and still are, a less expensive alternative to a “fully rated system,” where all the overcurrent protective devices have a short-circuit interrupting rating at least equal to the available short-circuit current. In a series rated system, the downstream overcurrent protective devices have a lower individual rating but the combination of the devices has an interrupting rating at least equal to the available short-circuit current. A **series rating** can be described as follows:

> A short-circuit interrupting rating assigned to a combination of two or more overcurrent protective devices which are connected in series and in which the rating of the downstream device(s) in the combination is less than the series rating. (National Electrical Manufacturers Association, “Series Ratings,” *IAEI NEWS,* Richardson, TX, March/April 1994, pp. 23-25.)

The validity of, at least pairs, of the series rated combinations has been confirmed via test protocols defined in Underwriters Laboratories Standard UL 489, *Molded-Case Circuit Breakers and Circuit-Breaker Enclosures.*

Series ratings include circuit breaker/circuit breaker combinations and fuse/circuit breaker combinations and schematically appear as shown in Figure 1.

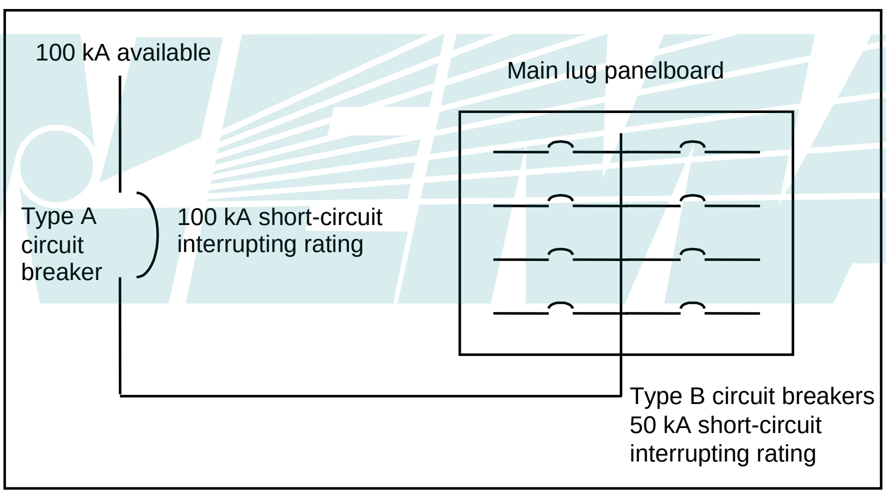

Figure 1
Schematic of 100 kA Circuit Breaker–to–Circuit Breaker Series Rating

It is important to note that a series rating is a short-circuit interrupting rating of a combination of overcurrent protective devices. There is a misconception that the upstream device in the series must limit the current to a level equal to the interrupting rating of the downstream devices in the series rated combination. This is incorrect. The rating is based on the combination of the devices operating together to interrupt the current. Because of this, the combination must be tested together to verify the performance just as any individual device must be tested to verify its performance. The specific role fulfilled by each device in the combination is not defined by standard or engineering practice.

There appears to be a great amount of confusion about series ratings. This white paper is intended to eliminate confusion.

Testing

First, a comparison of the test requirements for a short-circuit interrupting rating for an individual circuit breaker and a short-circuit interrupting rating for a series combination. The test requirements are from Underwriters Laboratories' Standard UL 489, *Molded-Case Circuit Breakers and Circuit-Breaker Enclosures.*

The short-circuit interrupting rating for an individual circuit breaker is established by conducting the sequence of tests below on the maximum ampere rating in the frame for each current and voltage rating. In addition, the minimum ampere rating in the frame is tested at the highest short-circuit current rating.

1) Calibration test to confirm that the circuit breaker will open within the required time and current.
2) "O" test, in which the fault is initiated with the circuit breaker in the closed position.
3) "CO" test, in which the same circuit breaker is closed on the fault.
4) Calibration test to make certain the circuit breaker is still functional.
5) Dielectric test.

The short-circuit interrupting rating for a series combination is established by conducting a similar sequence of tests. The difference is that the test circuit now includes an upstream device of the maximum ampere rating, and the test samples will now include branch circuit breakers of the minimum ampere rating, the maximum ampere rating, and the maximum ampere rating of any construction breaks[1]. Different test programs are required with different upstream devices, and different programs might be required for different voltage ratings. If a series test program is being done to cover more than two devices in series, this sequence must be repeated each time a downstream device is added. The first two devices in the series would go through this sequence, and then they would become the upstream device for a third downstream device. These three devices could then become the upstream device for a fourth downstream device, and so on.

When performing series tests, the results are somewhat different from the results of single circuit breaker testing. In a series test, the results can be as follows:

a) The downstream device trips.
b) The upstream device trips.
c) The upstream and the downstream devices trip.

If the result is that the downstream device trips successfully, no further testing is required on the combination. If the results are that the upstream device alone trips, or both the upstream and the downstream devices trip, further testing (intermediate testing) is required. This testing varies depending on whether the upstream device is a fuse or a circuit breaker, but it is similar in both situations and is aimed at the same thing. This intermediate testing is to determine the maximum level at which the downstream device operates independently to interrupt the circuit and to demonstrate that the device can safely interrupt that level of current. It should not be concluded that if a downstream circuit breaker is able to interrupt the series circuit successfully without the upstream device opening that the downstream circuit breaker is fully rated for the fault current value. Even if the upstream device did not open, the upstream device might have provided interruption assistance via its inherent impedance or momentary contact parting, thereby reducing the current that the downstream circuit breaker had to interrupt.

As noted earlier, a series rating of two or more overcurrent protective devices is a short-circuit interrupting rating of the combination. As such, the series rating is treated like a short-circuit rating of an individual circuit breaker by UL with follow-up testing conducted and witnessed by UL. If an individual circuit breaker fails this follow-up testing, UL prevents the manufacturer from marking the interrupting rating on the circuit

[1] **Construction break:** a significant difference in construction between circuit breakers of a given frame size, requiring additional type testing.

breaker. In the case of series ratings, since the rating actually appears on the panel where the circuit breaker is installed, UL requires the circuit breaker manufacturer to mark each of the production circuit breakers to indicate that they should not be used in the series application. This is why series ratings are restricted to the manufacturer of the downstream circuit breaker.

Testing versus Up-Over-and-Down and Up-and-Over, aka Engineered Ratings

The “Up-Over-and-Down” and “Up-and-Over” methods of selecting overcurrent protective devices, also known as “engineered ratings,” are fairly well known, so a detailed explanation of how these methods work will not be offered here. These methods are based on theoretical concepts; what will be discussed is the theory behind the methods and how they compare with series ratings.

These are methods by which combinations of fuses and circuit breakers allegedly can be selected by using the let-through characteristics of the fuses and the short-circuit current-interrupting rating of the circuit breaker. The theory states that if the fuses can limit the current to a value equal or lower than the interrupting rating value to which the circuit breaker was tested, the fuse can “protect” the circuit breaker. It is not a concept accepted by UL to establish short-circuit interrupting ratings for circuit breakers. The Recognized Component Directory (UL Yellow Book) provides several series ratings with fuse/circuit breaker combinations. The ratings for these combinations are tested ratings, just as they are for circuit breaker/circuit breaker combinations.

The methods are theoretical concepts based on what a static circuit breaker would do. Circuit breakers, however, are not static devices, they are dynamic. They are designed to interrupt the current by opening their contacts. Except for a very narrow group of circuit breakers with high withstand capability, they are not designed to remain closed and wait for another device to perform the function. At some multiple of the current rating of the circuit breaker, the circuit breaker will experience electrodynamic forces created within the circuit breaker that will cause the contacts to separate and create arc voltage, also known as dynamic impedance. Different circuit breaker designs employ different tripping mechanisms to ensure excessive contact parting does not occur before the circuit breaker mechanism unlatches and opens, but all circuit breakers have a range of current for which this contact parting behavior is acceptable and a trip will not necessarily occur. Fault current above the rating of the circuit breaker can cause this contact parting behavior to happen very quickly.

When fuses are used in circuits that do not create dynamic impedance, fuse performance is predictable. When the circuit contains active components capable of developing dynamic impedance, these analytical methods based on published fuse performance are not applicable. In the case of circuit breakers, the contacts will begin to part at current levels far below the interrupting rating of the circuit breaker. As soon as the contacts begin to part, impedance is introduced into the circuit by the arc. This impedance rapidly increases, thus limiting the current flow. The result is that the circuit is not the same as it was with static components. The circuit characteristics are different, and the fuse might not respond as it might have with only static components in the circuit. The dynamic impedance caused by the parting contacts lowers the current flowing in the circuit below that which would cause the fuse to interrupt sufficiently fast to protect the circuit breaker. Under these conditions, because of the reduced current, the fuse might not open fast enough, or not at all, and the circuit breaker will attempt to interrupt a current that it is not able to interrupt, thereby possibly causing a failure of the downstream device. This situation would be evident in series testing per the protocol described in UL 489, but is difficult to predict based on normally published circuit breaker and fuse performance data via the analytical methods proposed.

One of the misconceptions in applying “Engineered Ratings” methods is that unless a circuit breaker is marked “current limiting,” it does not limit the current. This is not the case. Circuit breakers, whether or not they are marked current limiting, limit the current during interruption because of the dynamic impedance during the fast contact parting described above. UL 489 and manufacturer published data do not provide information to determine how a circuit breaker performs. All circuit breaker designs are different and will perform differently. Circuit breakers marked current-limiting, as per UL requirements, will be accompanied by additional current-limiting curves that illustrate the current-limiting performance of the devices. The common denominator among designs is that they all provide the conductor protection they are intended to provide. Note that in series combinations, when there is more than one device opening, the current is limited far more than when a single device opens.

Because of the many variables involved, the only way to determine if two devices can be used in series is by test. Under test conditions, the interaction of the devices is examined and it is determined whether or not the combination works.

***National Electrical Code*® *(NEC)* Requirements, Based on the 2014 Edition**

Since a series rating is a short-circuit interrupting rating, all *NEC* rules dealing with interrupting ratings, including sections 110.9, 110.22(C), and 240.86, should be used when applying devices with a series rating. Two of these sections deal specifically with series ratings.

NEC Section 110.22(C) requires the equipment enclosures to be marked if a "tested series combination rating" is used. The intent of this requirement is to require the installer to label the equipment such that the existence of the "tested series combination rating" is evident and should be taken into account in any future modifications of the equipment when a circuit breaker or fuse replacement is considered. Any circuit breaker replaced must maintain the required series rating or be fully rated for the available fault current. The marking is defined as follows:

CAUTION: __ SERIES COMBINATION SYSTEM RATED __ AMPERES.
IDENTIFIED REPLACEMENT COMPONENTS REQUIRED.

This marking should be applied to each panelboard where a circuit breaker is installed, based on a series rating and not simply the first or last panelboard. The caution marking should appear to an installer or maintenance personnel at each location that he or she might be working. Each of these panelboards must also be marked with the circuit breakers and fuses that can be used in the series rating so that all information needed by the installer or maintenance personnel is provided.

NEC Section 240.86(B) provides the guidelines for using a circuit breaker in a "tested series combination rating." It requires that the series combination be marked on the end use equipment. Manufacturers of panelboards, switchboards, etc., identify the devices with the acceptable series combinations on labels within the equipment, or they might provide a reference to a separate publication that identifies the suitable combination ratings for that apparatus. The combinations are normally found in the UL *Recognized Component Directory* (Yellow Book). However, not all available component series ratings are available within all equipment, and the definitive reference is the label in the equipment or the manufacturer's documents referenced by that label. UL-recognized series ratings able to be used within specific equipment should be listed in the UL file for that equipment in addition to being listed in the Yellow Book.

Section 240.86(A) describes requirements for device combinations "selected under engineering supervision in existing installations." The normal methods are the Up-Over-and-Down and Up-and-Over methods previously described. This subject is covered further in NEMA white paper *Engineered Series Ratings: Is It Practical?*

Motor Contribution

In the event of a short-circuit in a system in which there are motors running, the potential motor contribution to the short-circuit current must be considered by the electrical system designer and installer. This is true whether the overcurrent protective devices are fully rated, have been installed based on calculations, or if series ratings are used. Motor contribution adds complexity that must be properly considered whether the overcurrent protective devices are fully rated or if series combination ratings are used.

With fully rated systems, this analysis is straightforward. For these systems, the motor contribution can be calculated and added to the available current from the transformer and the interrupting rating of the overcurrent device can be adjusted accordingly.

With a series rating, the task is a little more difficult if the motor contribution is injected into the system downstream of the first circuit breaker or fuse in the series but upstream of the lower-rated components in the series rating combination. Since the downstream circuit breaker depends on the upstream circuit breaker or fuse as part of the interrupting rating, and the motor contribution does not flow through that upstream device, motor contribution must be dealt with differently.

Example: To achieve the proper series combination rating for circuit breakers A→B, as shown in Figure 2, the rating must be higher than the sum of the fault contribution from the sources and the contribution from motors M1 and M2. In addition, the motor full load current from M2 must not be larger than 1% of the rating of circuit breaker B. To achieve a proper series rating for circuit breakers A→C, the pair must be rated for the sum of the Utility or upstream sources and M1.

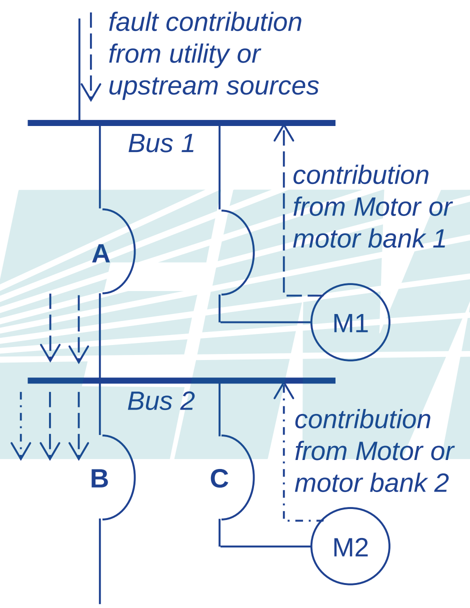

Figure 2
Series Rating in Circuits with Motor Contribution

Motors fed through solid state variable speed drives do not normally contribute significant fault current. Motor control centers with primarily motor loads are not typically able to take advantage of series combination ratings.

Series Combination versus Selective Coordination

Selective coordination involves the selection, arrangement, and adjustment of overcurrent protective devices so that a particular overcurrent protective device will open for a particular fault or overload condition. The optimum situation is for only the overcurrent protective device closest to the overload to open regardless the magnitude or type of overcurrent.

A pair of circuit breakers can be selected and adjusted such that they are selectively coordinated up to some level of fault current. Circuit breaker pairs can also be selected that are "series rated." In a series rated combination, the pair of circuit breakers is tested to ensure that together they provide sufficient fault current–interrupting capability to interrupt a high level of fault current that might exceed the short-circuit rating stated on the label of the downstream circuit breaker. Over some range of fault current, overcurrent devices that are series rated can also be selectively coordinated. If two devices are series rated, it does not automatically exclude them from being selectively coordinated over some range of available fault current. The exact mechanism of how this can be achieved is beyond the scope of this paper.

While achieving both a series rating and selective coordination between two circuit breakers is generally not common, there are exceptions to this rule. The ability of protective devices to be selectively coordinated is typically shown by the device's respective time current curves or manufacturer's selectivity tables.

Advanced Technical Concepts

As noted above, many molded case circuit breakers limit fault current regardless of whether or not the devices are marked current-limiting.

Many modern circuit breakers implement some type of designed magnetic repulsion of contacts for interruption of fault currents. This repulsion force causes the contacts to open at particular current levels independent of the circuit breaker's tripping mechanism. The speed of contact separation is increased beyond the speed of only the mechanism. The result is a rapid increase in the arc impedance, thus limiting the current and causing faster interruption of the circuit. However, even circuit breakers that do not implement specific designs to amplify repulsion forces will inherently generate repulsion forces. Even these smaller repulsive forces are enough to cause contacts to separate and cause current-limiting arcing voltage to be developed under high fault conditions.

Circuit breakers today also employ much better systems to accelerate opening behavior, as well as to control and extinguish the arc. This also aids in limiting fault current and speeding interruption that might further complicate any analytical method that might be devised to predict circuit breaker behavior within multiple circuit breaker systems.

UL *Recognized Component Directory* (Yellow Book)

The UL *Recognized Component Directory* identifies those products that have been submitted to UL but are incomplete in certain constructional features or restricted in performance capabilities. Some additional characterization is needed before these products are used in listed equipment. Series rated combinations are incomplete because a short-circuit interrupting rating marking is required on the equipment to allow the series combination rating.

The Yellow Book may be used by panelboard and switchboard manufacturers to identify the series rated combinations that may be marked on their equipment. If a series rating is to be used in the panelboard or switchboard, this is indicated by the manufacturer when the panelboard or switchboard is submitted to UL for series combination testing. UL completes the submittal by marking the interrupting rating of the series combination on the equipment. The Yellow Book is not intended as a list that can simply be used by the equipment installer to identify combinations that can be assembled in the field.

Note that all series combinations might not be published in the Yellow Book, but all series rated combinations that are marked on UL Listed equipment are tested—whether or not they appear in the Yellow Book. A number of additional combinations are Recognized by UL and included in the manufacturers' reports but might not be published. These could be special combinations that the manufacturer intends only for certain products and not for more general use. These unpublished combinations are used by the manufacturer and UL to complete the submittal of the equipment, as with any other series. Again, the final determination of application is the marking on the equipment that is part of the UL Listing of the panelboard.

How to Use Series Ratings

How do you determine if series ratings exist? What are they? Can you use them? Determining the answers to these questions involves following the same approach that would be used to determine when to use an individual circuit breaker.

Using panelboards as an example: A panelboard is required to have a short-circuit current rating marked on it. The panelboard will also specify the circuit breakers that are acceptable for use in it. The same is true if series rated circuit breakers can be used. The panelboard will be marked with a short-circuit current rating and with those device combinations that are approved for use. This marking must be on the panelboard where the downstream circuit breaker will be installed, even if the upstream circuit breaker is remotely located.

For example, an installation with 100 kA available that consists of the following equipment available from one manufacturer:

- 200 ampere circuit breaker enclosure rated 100 kA. The manufacturer’s “Type A” circuit breaker rated 100 kA is being used.
- 200 ampere main-lug panelboard. The manufacturer’s “Type B” circuit breakers rated 50 kA are being used.
- 50 ampere main-lug subpanel. The manufacturer’s “Type C” circuit breakers rated 10 kA are being used.

Schematically, this installation appears as shown in Figure 3 below.

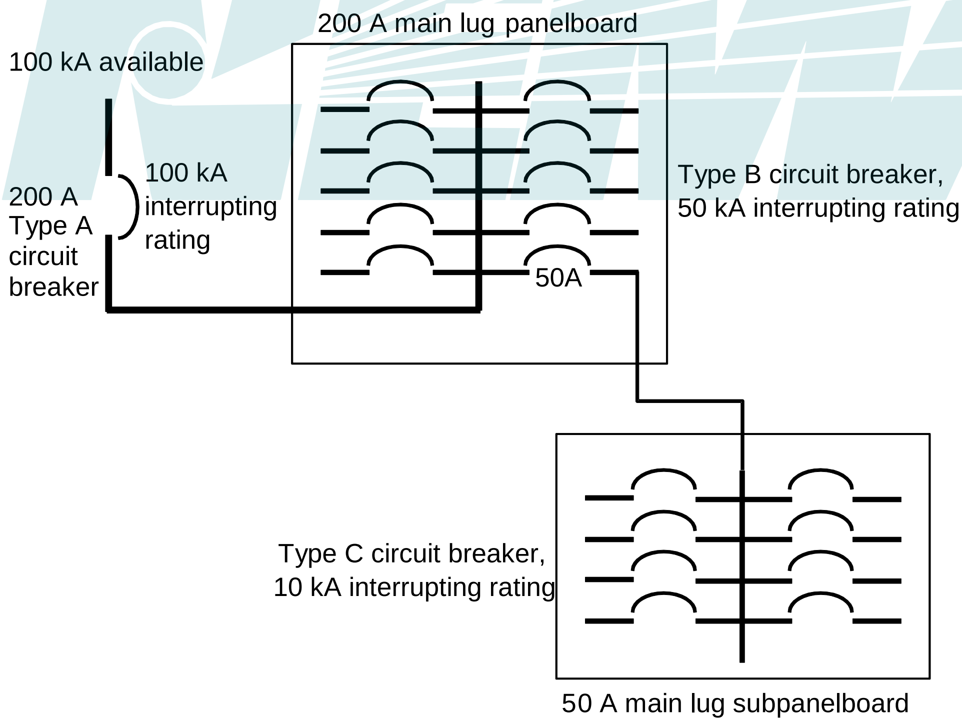

Figure 3
Series Rating Example: Remote Feeder, Panel, and Subpanel

In this example, the service disconnect would be fully rated for the available current (100 kA) and would not have any series ratings marked on it. No series rating is being employed at this point.

The 200 ampere main lug panelboard must have a maximum short-circuit current rating equal to the available current at its bus. Say that current is close to 100 kA, so a 100 kA rating is desirable. To properly use the 50 kA circuit breakers in the panelboard, the panelboard must be marked with a series rating indicating that when the manufacturer's "Type A" circuit breakers are installed upstream of this panelboard and the manufacturer's "Type B" circuit breakers are installed in the panelboard, the panelboard can be used on a circuit with 100 kA available.

Say the 50 A subpanel is sufficiently close to also need an interruption rating of 100 kA. The 50 A subpanel should also be marked with a short-circuit current rating of 100 kA. This rating can be achieved if the series combination of circuit breakers A, B, and C are series rated for 100 kA or if A and B are so rated and A and C are so rated. A third way to accomplish this would be if circuit breakers A and C are series rated for 100 kA and circuit breaker B is fully rated but not part of a series rating.

Figure 4 is another example of possible series rating based on various two-device series rating or one three-device series rating.

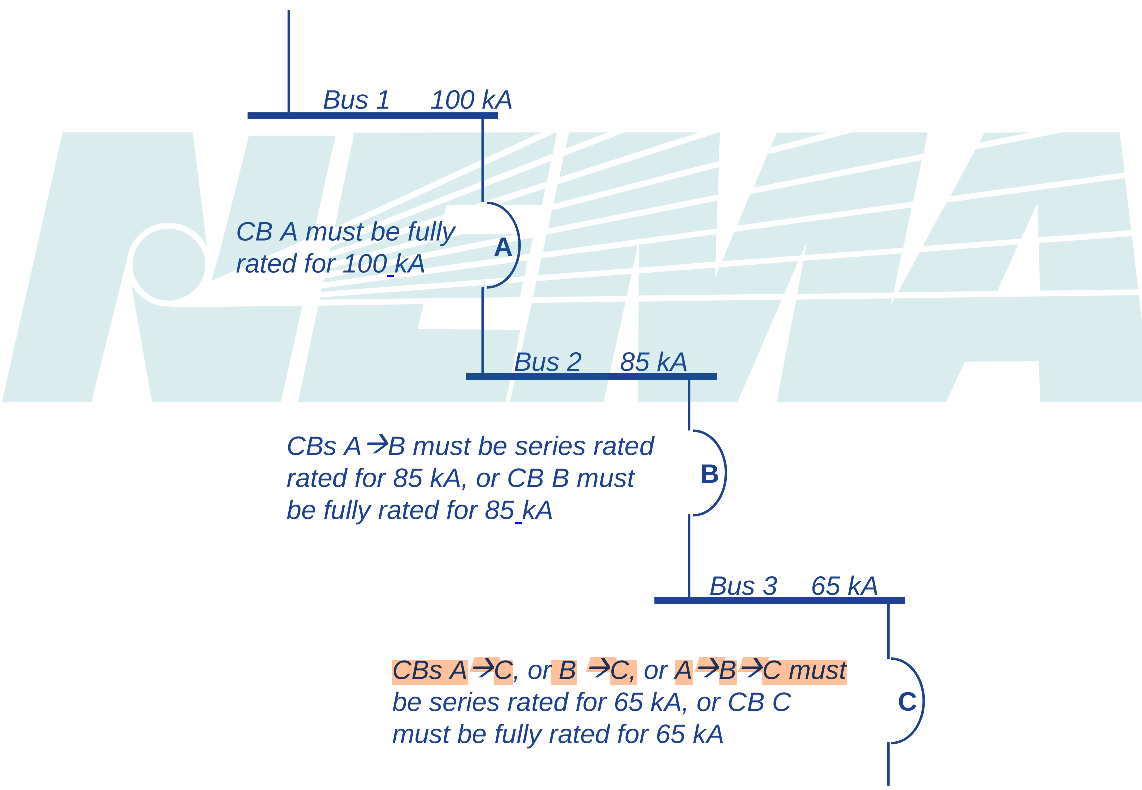

Figure 4
Example of Multiple Levels of Series Ratings

Ratings in Equipment: How to Specify Series Rated Equipment

When equipment is specified where series ratings are acceptable, the designer should indicate the acceptability of these series ratings on contract documents. Manufacturers should provide documentation of the series ratings available for use in the equipment provided. Designers should be careful using the

UL Yellow book or documents listing the series rating of recognized components, as all of the component series ratings might not be available in the desired equipment.

Conclusion

Series ratings are viable cost-effective alternatives to fully rated systems. They include not only circuit breaker/circuit breaker combinations but also fuse/circuit breaker combinations. They are ratings established by the downstream circuit breaker manufacturer based on tests that are identical to the tests for individual circuit breakers. No theoretical or analytical methods exist in commonly available published data to make this determination. Testing is the only way to demonstrate that a combination can safely interrupt the available fault current.

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