

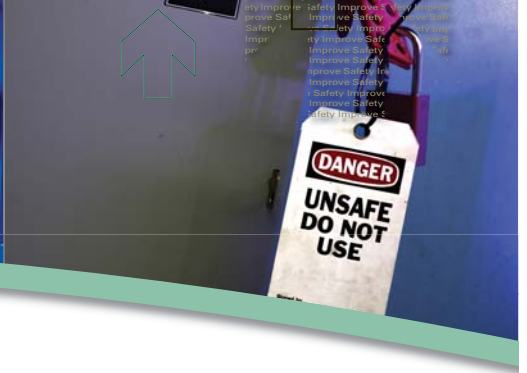
USING CURRENT-LIMITING FUSES TO INCREASE SHORT CIRCUIT CURRENT RATINGS OF INDUSTRIAL CONTROL PANELS



INDUSTRIAL CONTROL PANEL ICP#2

Serial Number LF003292
Current 47A
Voltage 480Y/277V
Phase & Freq 3ph/60Hz
SCCR 50kA
Diagram Numbers LM 8.1 THRU LM8.5

XYZ Machine Company
City, State, USA





Executive Summary

All states and local electrical Authorities Having Jurisdiction (AHJ) that have adopted the 2005 edition of the National Electrical Code® (NEC®)¹ require industrial control panels to be marked with a Short Circuit Current Rating (SCCR). Since April 25th, 2006 all UL Listed industrial control panels must be marked and labeled with a Short Circuit Current Rating.

The Short Circuit Current Rating is the maximum current the control panel can safely withstand. If the available fault current of the electrical system where the panel is installed exceeds the SCCR of the panel and a short circuit occurs, catastrophic damage to the panel may occur and electrical workers and others are put at risk of injury. It is the responsibility of the consulting or electrical design engineer to verify that all industrial control panels are applied in a manner such that the panel's SCCR is greater than the system's available fault current. It is the responsibility of the industrial control panel manufacturer to provide accurate SCCR information to the consulting engineer and inspector through required labels and published technical information.

According to the National Electrical Code® the industrial control panel manufacturer can determine a panel's SCCR using one of two methods. The first is to test the panel at its labeled SCCR in a witnessed test at a National Recognized Testing Lab (NRTL). The alternate method that the manufacturer can use is to apply the standardized tables of UL508A, standard for industrial control panels. The mechanics of performing both of these methods are covered in detail in this paper.

There are equally offsetting trade-offs between testing your panels or applying the UL508A tables. By using current-limiting devices and testing your panel, you will typically achieve a higher SCCR for your panel. However, because each unique panel design needs to be tested, for some manufacturers, this method can become prohibitively expensive and time consuming. In these cases, the UL508A table method may be used.

Finally, short circuit current ratings of a panel can be increased with minimal costs if attention is paid to the SCCR in the design stage. By using current limiting circuit protection devices and carefully selecting other high withstand rated components, the final SCCR of the panel can be increased to a level acceptable to consulting engineers and inspectors. This creates an opportunity for a creative manufacturer with good design capabilities to build a real competitive advantage of a high SCCR into every panel they design and manufacture.

What is a SCCR?

The Short Circuit Current Rating refers to the maximum current, usually expressed in kA at a specified voltage, that a device or system can safely withstand for a specified time (such as 0.05 seconds), or until a specified fuse or circuit breaker opens and clears the circuit. Many UL approved individual power components such as contactors, overload relays, and motor controllers are marked with a SCCR (sometimes referred to as withstand rating). Overcurrent protective devices such as fuses and circuit breakers are generally marked with an Interrupting Rating (IR) or Ampere Interrupting Capacity (AIC).

Beginning with the 2005 edition of NEC Article 409, Industrial Control Panels (ICP) that contain power controls for compressors, pumps, fans, drive motors, air-conditioning units, resistive heating controls, lighting loads, and other assemblies of components that control power to utilization equipment must have a SCCR clearly marked on its label. These labels allow installers and inspectors to compare fault current studies at the facility where the panels are intended to be installed, to the SCCR of the control panel to minimize potential hazards in industrial or commercial facilities.

As demand for electric power continues to increase and utility companies update their equipment or system of supply, available fault currents within industrial facilities can increase dramatically. If the available fault current at the equipment exceeds the SCCR of the panel, the results can be catastrophic.

The most dangerous and common misconception by equipment manufacturers regarding the SCCR is that the interrupting capacity or interrupting rating of the main circuit protection device is also the SCCR of the panel in which it is installed. This practice can create an unsafe condition and confusion as to where the panel can be used safely. For example, before the introduction of the 2005 NEC, if a panel had a main feeder circuit protective device with an interrupting rating of 22 kA, some manufacturers were labeling the panel with an SCCR of 22 kA. However, each power component within the panel has a different Short Circuit Current Rating or Interrupting Rating, most of which are likely to be less than 22 kA. If a 22 kA fault were to occur, the main circuit protective device may be able to safely interrupt the fault, but one or more of the power components within the panel could violently explode or catch on fire.

In 2005, the NEC addressed this problem with the advent of required labels on equipment that clearly state the equipment's SCCR according to an approved



method. The 2005 NEC specifically requires SCCR markings for all:

- Industrial control panels [Article 409]
- Industrial machinery electrical panels [Article 670]
- Multiple motor HVAC equipment [Article 440]
- Meter disconnect switches [Article 230]
- Multiple motor controllers [Article 430]

Although SCCR markings and labels are required by several NEC Articles, we will examine how to determine the SCCR of Industrial Control Panels according to NEC Article 409.

The NEC has added SCCR labeling requirements to create a safe installation and help manufacturers, owners, and managers meet OSHA safety regulations and NFPA requirements. More specifically, the new Article requires analysis of panels and facilities for potential electrical hazards to establish a safe work environment. SCCR markings are especially important when industrial control panels are moved from one location to another, or when available fault currents are increased by local utility companies or by changes within a facility. For safety and reliability, it is essential to compare accurate SCCR markings on equipment with available fault currents on a regular basis to make sure the equipment is reliable, safe to use, and workers are protected from any potential hazards.

Overcurrent Protective Device Interrupting Rating

Interrupting Rating [sometimes referred to as Ampere Interrupting Capacity (AIC)] refers to the maximum fault current that circuit protective devices such as fuses and circuit breakers may be required to safely open (interrupt). Although there are differences in the way fuses and circuit breakers are tested, the Interrupting Rating or Interrupting Capacity of a fuse or circuit breaker is assumed to be its SCCR.

Article 110.9 of the NEC requires overcurrent protective devices to have interrupting ratings sufficient for the available fault current and voltage at the equipment it is intended to protect. Article 110.10 of the NEC specifically requires that overcurrent protective devices and the components they are designed to protect are coordinated so that excessive damage does not occur to any component or circuit in the event of a short circuit fault.

Fuses and circuit breakers that are Listed or

Recognized by a NRTL are tested under laboratory conditions and verified to safely interrupt certain fault currents. In order to obtain approvals, a fuse must open safely and not damage itself or anything around it, nor vent hot gases that could ignite flammable surroundings. Circuit breakers must also open safely under controlled conditions and not damage anything nearby or cause it to catch on fire. Circuit breakers however, may vent high temperature gases and can be a source of ignition in hazardous areas. It is also important to keep in mind that some circuit breakers or supplementary protectors are tested and approved to safely interrupt a high level short circuit current only one time. After interrupting a short circuit at or near their interrupting rating, some circuit breakers may not remain operable or approved for further use. Always check with the overcurrent protective device manufacturer and with UL or the applicable safety agency listing sheets to verify the maximum interrupting current and type of rating of all overcurrent protective devices being considered for use.

How do you determine the SCCR of an Industrial Control Panel?

NEC Article 409.110 states that the Short Circuit Current Rating of an industrial control panel is based either on the Short Circuit Current Rating of a Listed and Labeled assembly, or by utilizing an approved method. UL 508A Supplement SB is given as one example of an approved method. Other approved methods are left to the discretion of the local electrical inspector and may involve a stamped engineered analysis by a licensed professional engineer in the state or local jurisdiction where the panel is installed.

Submitting a panel to UL or to another NRTL to be tested and Listed may be the preferred method for some original equipment manufacturers that are manufacturing the same panel for a specific application time and time again, or when the panel is part of a larger piece of equipment which is also Listed. Another reason to submit a panel for approval testing may be to obtain higher Short Circuit Current Ratings than other approved methods can provide.

The UL 508A Supplement SB method of assigning the SCCR to an industrial control panel does not require the panel be Listed. Supplement SB describes how to assign the SCCR to a panel based on the ratings of the individual power components and types of current-limiting power devices used within the panel. As of April 25, 2006, manufacturers of custom control panels that are certified by UL to apply the UL Listing mark must follow the construction standards and



marking requirements of UL 508A Supplement SB.

Manufacturers who are building only one or a few custom panels at a time, or manufacturing panels that have several optional configurations may prefer to use the UL 508A Supplement SB method to establish the SCCR of their panel to meet NEC Article 409 requirements. The UL 508A Supplement SB method, however, may not provide an adequate SCCR for the application. In these situations, the panel must be re-engineered or Listed and approved by another method.

When panels with fuses and circuit breakers are Listed by a NRTL such as UL or CSA, the equipment instructions and labels must indicate that the equipment shall be protected by the specified fuse class and rating, or by a specific make, type, and rating of circuit breaker.

Panels that are not Listed will be scrutinized by the local electrical inspector (AHJ) for the required NEC 409 SCCR markings. If requested by the local AHJ, manufacturers must keep detailed records of their bill

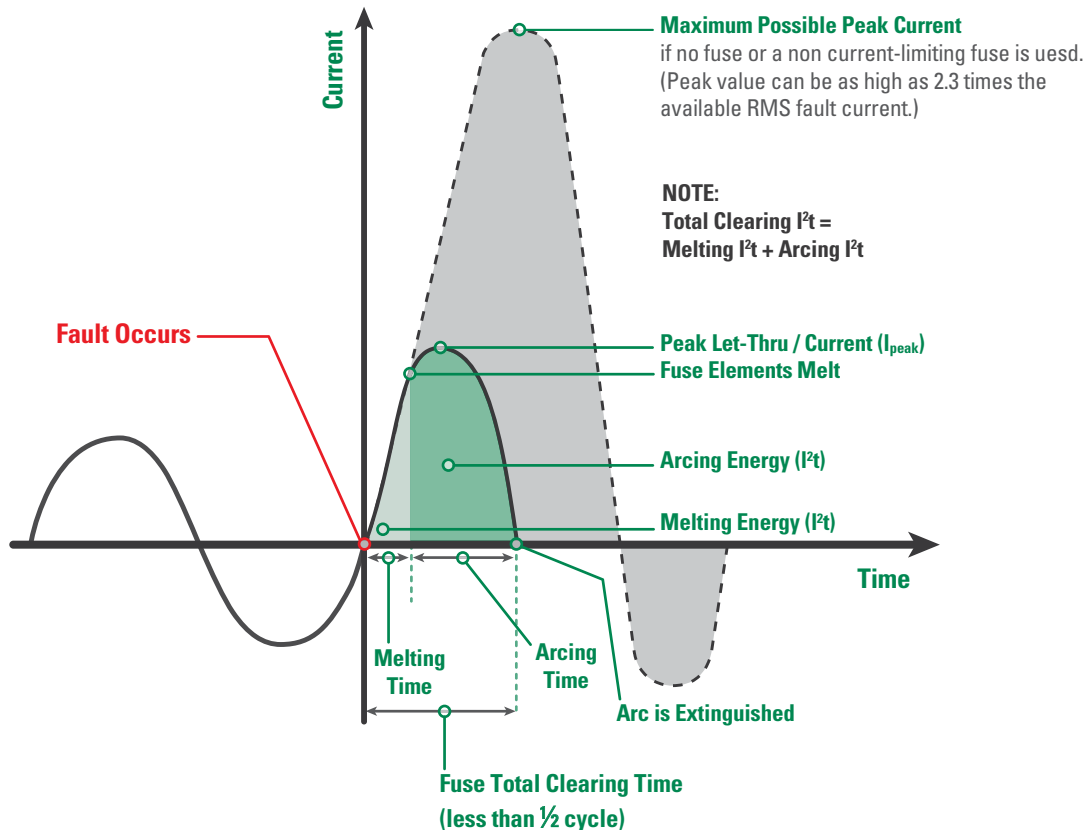
of materials, SCCRs of all components, and the method used to determine the overall SCCR of the panel.

What is Current Limitation, and How Does Current Limitation Increase Short Circuit Current Ratings?

Section 240.2 of the NEC states that a current-limiting device is one that reduces the peak let-thru current to a value substantially less than the potential peak current that would occur if the current-limiting device were not used. When applied to current-limiting fuses, a current-limiting fuse is one that opens and clears the current in less than 1/2 of an AC cycle (0.0083 sec.). See Figure 1.

Figure 1 shows the maximum instantaneous peak current during the first 1/2 cycle after initiation of a fault. Depending on the power factor and when the fault occurs, the maximum possible instantaneous peak current (I_{peak}) without current limitation can be as high as 2.3 times the available RMS fault current when the fault occurs. As shown, if a current-limiting fuse

Figure 1





is used, the maximum instantaneous peak current is limited to a small fraction of the peak current that could possibly flow if the fuse were not used. The current-limiting fuse link melts and clears the circuit in less than 0.0083 second. The area under the curve is known as the I²t let through energy of the fuse. The lower the I²t is, the lower the destructive thermal energy is that passes through the circuit before it is interrupted.

RMS vs. I_{peak}

It is important to point out that the SCCR of components or panels is expressed in RMS kA and not in instantaneous peak current (I_{peak}). RMS (Root-Mean-Squared) current is an expression of effective current over a period of time. As discussed above, if a short circuit occurs, the instantaneous peak current can be up to 2.3 times the available RMS current at the point of the fault. In other words, if the available RMS short circuit current were 10 kA, the I_{peak} could be 23 kA. Conversely, if the I_{peak} of a current-limiting fuse is 23 kA, the equivalent or apparent RMS value is 0.435 times the I_{peak}, or 10 kA. When properly applied, current-limiting fuses will limit the I_{peak} and apparent RMS short circuit current to a level that the rest of the panel can safely handle. The effect of current-limiting fuses is commonly used to estimate the SCCR of a panel prior to testing by UL or another NRTL. The use of current-limiting fuses is sometimes referred to as the "Tested Method" of estimating the SCCR of industrial control panels. If acceptable by the local AHJ, this method

may also be used in place of UL 508A Table SB4.2 in engineered solutions to establish the SCCR of certain industrial control panels.

Current Limitation and Peak Let-through Charts

Current-limiting fuses operating in their current-limiting range will limit the maximum instantaneous peak current to a value substantially less than the peak current that could flow if the fuse were not in the circuit. Figure 2 shows the relationship between the available symmetrical RMS fault current (horizontal axis) and the maximum instantaneous peak current (I_{peak}) (vertical axis) possible if a short circuit occurs. Line A-B represents the maximum possible instantaneous peak current under worst-case conditions (15% power factor, asymmetrical), or 2.3 times the available symmetrical RMS fault current. The other lines in Figure 2 represent the effects of various ampere ratings of typical current-limiting fuses. For example, if the available symmetrical RMS fault current (horizontal axis) at the line side terminals of a certain panel were 100kA, the maximum instantaneous peak current possible without current limitation would be 233,000 amperes (line A-B). However, if a 200 Ampere current-limiting fuse were used, the maximum instantaneous peak current (I_{peak}) would be limited to approximately 20,000 amperes. If a 30 ampere fuse were used, the maximum instantaneous peak current (I_{peak}) would be limited to approximately 6000 amperes.

Figure 2

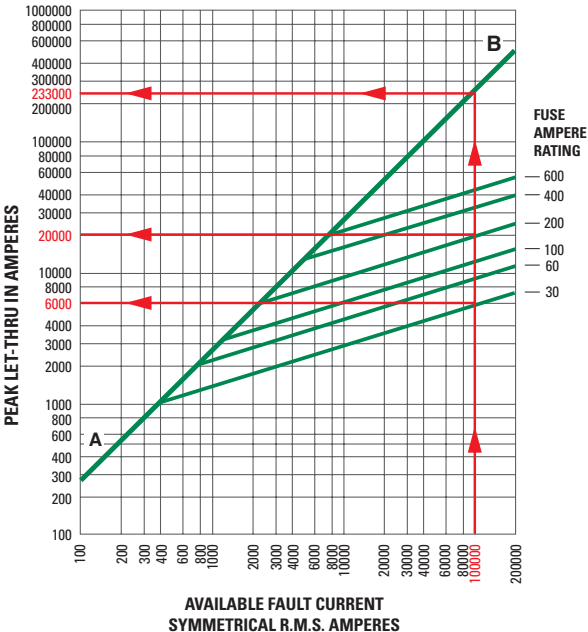
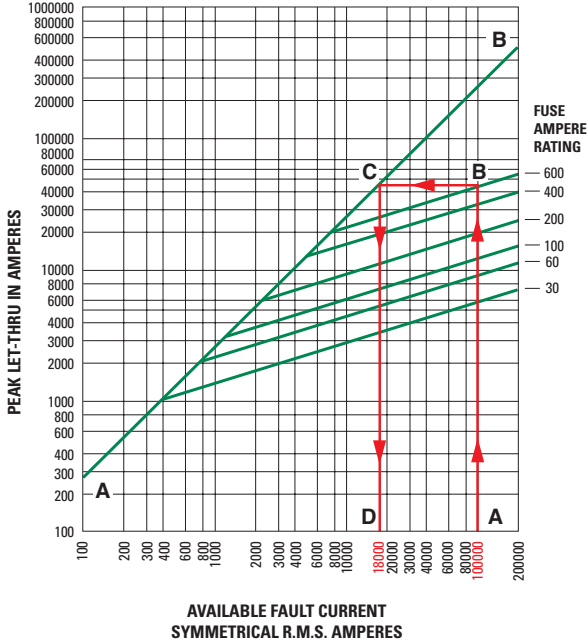


Figure 3





Tested Method

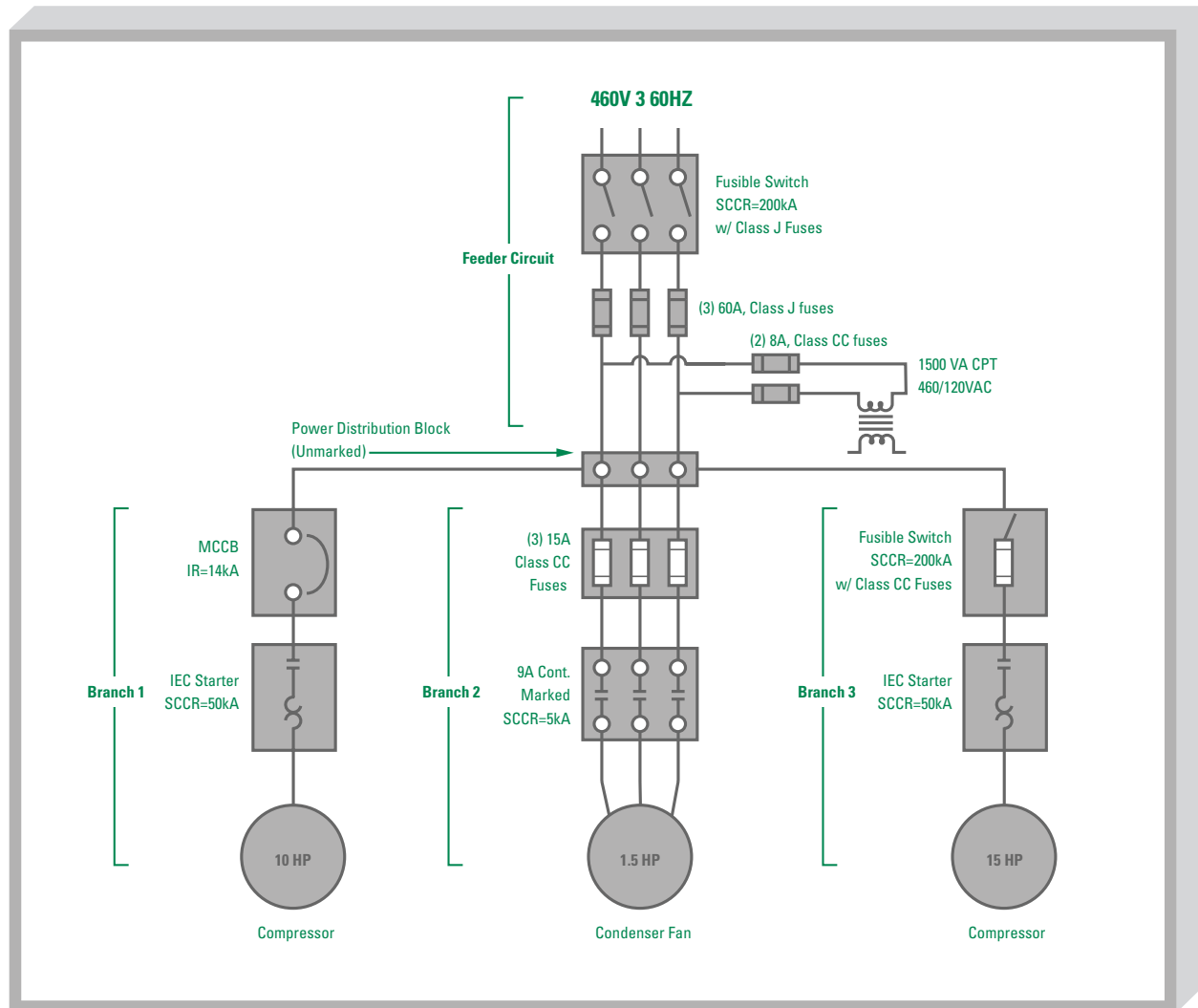
Figure 3 shows how the peak let-thru charts can be used to estimate the equivalent or apparent symmetrical RMS fault current that a system can withstand. For example, if the available symmetrical RMS fault current at the line side terminals of a 600 Ampere current-limiting fuse were 100 kA (Point A), the fuse opens within the first ½ cycle and limits the maximum instantaneous peak current to no more than 45 kA (Point B). An instantaneous peak current (I_{peak}) of 45 kA (Point B) is the same maximum instantaneous peak current (Point C) that 18 kA of RMS current can generate (Point D). In other words, if the actual available

fault current is 100 kA, a 600 Ampere current-limiting fuse will limit the I_{peak} to an equivalent available RMS current of 18 kA. Since the highest possible equivalent RMS fault current is 18 kA, all components in series with the fuse with a SCCR of 18 kA or higher will be safely protected, making the combination capable of surviving up to a potential 100 kA fault.

Using peak let-thru charts to estimate the SCCR of industrial control panels

Before you submit your industrial control panel to UL or to another NRTL for approval testing, you can use the “Tested Method” to estimate the maximum

Figure 4



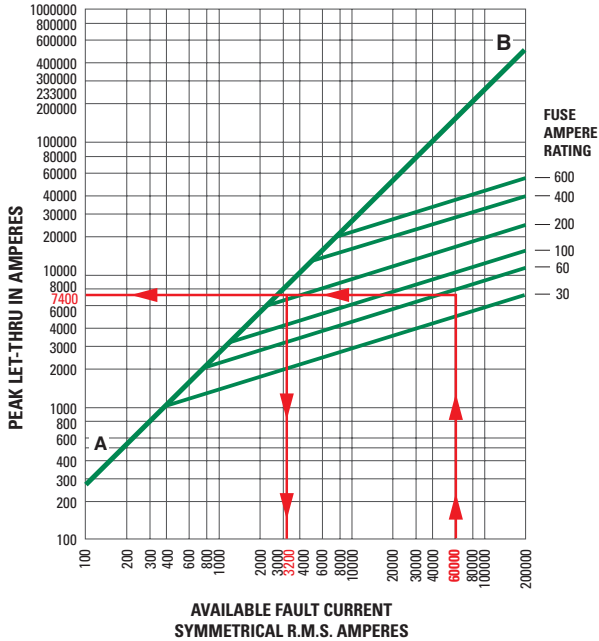


Figure 5: Peak Let-Thru Curve for Littelfuse JTD_ID Class J fuses

prospective RMS fault current, or SCCR, that the panel will safely handle. Let’s examine an example of a typical industrial control panel. See Figure 4.

In this example, the panel is to be installed in a facility where the available RMS fault current is 60,000 Amperes at 460 VAC. The main feeder circuit in the panel consists of a fusible disconnect switch with three Littelfuse JTD_ID 60 Ampere UL Class J fuses. The least rated SCCR component in the panel has been determined to be 10 kA. Therefore, the question we need to answer is: If a prospective 60 kA symmetrical RMS fault occurs, will the 60 Ampere JTD_ID fuses limit the apparent RMS symmetrical let-through current to 10 kA or less? Let’s take a look at the peak let-through curves for the family of JTD_ID fuses.

Using the Peak Let-Thru Curve (Fig.5), we see that at a prospective available symmetrical RMS fault current of 60,000 Amperes, the 60A Class J fuses limits the maximum instantaneous peak current (I_{peak}) to approximately 7400 Amperes. Moving horizontally over to the maximum instantaneous peak current line and downward back to the prospective available RMS symmetrical fault line, we see that the apparent RMS symmetrical fault current is approximately 3200 Amperes.

Since the 60 Ampere Class J fuses limit the maximum equivalent RMS fault current available to the other components in the panel, it can safely protect any component that has a SCCR over 3200 Amperes if a prospective RMS symmetrical fault current of 60,000 Amperes would occur.

If there are any circuit breakers or fuses in branch circuits, such as shown in Figure 4, care must be taken to make sure that the threshold current of the current-limiting feeder fuse is not greater than the interrupting rating of any non current-limiting branch circuit overcurrent devices. In the above example, the threshold current of the 60 Ampere Class J fuse is approximately 1000 Amperes, well below the interrupting rating of the 14kA circuit breaker in Branch Circuit No. 1.

Therefore, if tested and Listed by a NRTL, the SCCR of this panel could be 60,000 Amperes or more when using 60 Ampere Littelfuse JTD_ID Class J fuses. In fact, if the prospective available symmetrical RMS fault current were 200 kA, the fuses would limit the apparent RMS fault current to only 4000 Amperes, safely protecting all components within the panel.

Using the UL 508A Supplement SB method to determine the SCCR of industrial control panels

Manufacturers of industrial control panels that are certified by UL to affix the UL label to their equipment must follow the construction standards and requirements of UL Standard 508A. On April 25, 2006, the SCCR labeling requirements of UL 508A Supplement SB became mandatory. Although the standard refers to industrial control panels, the requirements and methods of UL 508A Supplement SB can be applied to any control panel that controls and provides power to all types of utilization equipment.

As mentioned previously, UL 508A Supplement SB provides a method of assigning the SCCR to an industrial control panel based on the types of overcurrent protective devices and the ratings of components used within the panel. According to Supplement SB, the SCCR of an industrial control panel is equal to the SCCR of:

- The lowest rated component, or
- The lowest rated UL approved series rated combination, or
- The SCCR of an approved series combination according to the standard.



For the same reason all equipment within the electrical distribution system of a facility must be rated to handle a worst-case scenario to completely protect people and equipment, every component within an industrial control panel must also be designed to perform in a worst-case scenario.

UL 508A Supplement SB currently does not utilize the apparent RMS let-through current of current-limiting fuses to establish the SCCR of industrial control panels. It compares the UL maximum allowable instantaneous peak let through current (I_{peak}) during the first ½ cycle of current-limiting fuses with the RMS SCCR of the various components used within the panel.

UL 508A Supplement SB4.1 describes three steps to establish the SCCR of industrial control panels:

Step 1

Determine the SCCR of all individual power components including UL certified and approved series rated combinations.

Step 2

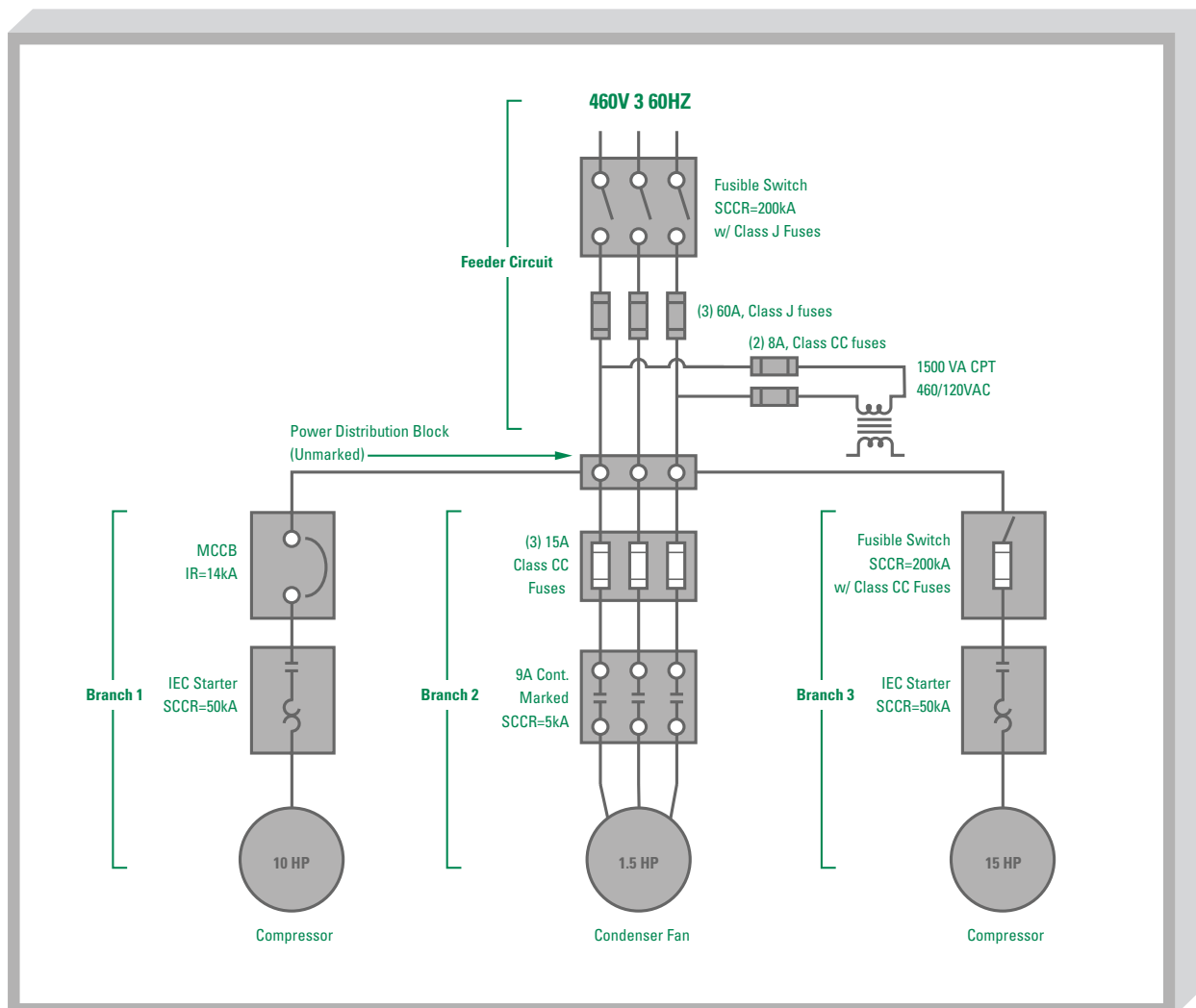
Modify the SCCR of certain component combinations if current-limiting fuses are used in the feeder circuit.

Step 3

Apply the lowest rated SCCR of any power component, overcurrent protective device, or modified combination to the SCCR of the panel.

In order to understand each step listed above, let us look at an example of a typical industrial control panel and complete each step according to the standard.

Figure 6





Panel Example

Using UL 508A Supplement SB and the steps listed above, determine the SCCR of the panel shown in Figure 6.

Step 1

Determine the SCCR of all individual power components including UL certified and approved series rated combinations.

The first step in establishing the SCCR of the control panel assembly is to analyze and record the SCCRs of all the individual power components and UL certified and approved combinations within the panel. All power components that are used to control and distribute power to individual motors, drives, and other loads outside or inside the enclosure must be analyzed. Peripheral items such as current measuring

transformers and items on the secondary side of current limited control power transformers including push buttons and contactor coils that are not in the direct power circuit paths, do not have to be analyzed.

Many power components such as fuses, circuit breakers, switches, contactors, overload relays, and motor controllers are marked with an interrupting rating or SCCR. Some items may not be marked, but the manufacturer may publish the short circuit current rating in their literature or in their operating instructions. For those items that are not marked with an SCCR nor have information provided by the manufacturer, Table SB4.1² (see Figure 7) of UL 508A Supplement SB provides an assumed maximum short circuit current rating. All power components within the panel must be documented and their short circuit current ratings recorded.

Figure 7: Table SB4.1. Assumed maximum short circuit current rating for unmarked components

Table SB4.1² ASSUMED MAXIMUM SHORT CIRCUIT CURRENT RATING FOR UNMARKED COMPONENTS

Table SB4.1 effective April 25, 2006

Component	Short circuit current rating, kA
Bus bars	10
Circuit breaker (including GFCI type)	5
Current meters	^a
Current shunt	10
Fuseholder	10
Industrial control equipment:	
a. Auxiliary devices (overload relay)	5
b. Switches (other than mercury tube type)	5
c. Mercury tube switches	
Rated over 60 amperes or over 250 volts	5
Rated 250 volts or less, 60 amperes or less, and over 2kVA	3.5
Rated 250 volts or less and 2 kVA or less	1
Motor controller, rated in horsepower (kW)	
a. 0 - 50 (0 - 37.3)	5 ^c
b. 51 - 200 (38 - 149)	10 ^c
c. 201 - 400 (150 - 298)	18 ^c
d. 401 - 600 (299 - 447)	30 ^c
e. 601 - 900 (448 - 671)	42 ^c
f. 901 - 1500 (672 - 1193)	85 ^c
Meter Socket base	10
Miniature or miscellaneous fuse	10 ^b
Receptacle (GFCI type)	2
Receptacle (other than GFCI type)	10
Supplementary protector	0.2
Switch unit	5
Terminal block or power distribution block	10

^a A short circuit current rating is not required when connected via a current transformer or current shunt. A directly connected current meter shall have a marked short circuit current rating.

^b The use of a miniature fuse is limited to 125-volt circuits.

^c Standard fault current rating for motor controller rated within specified horsepower range.



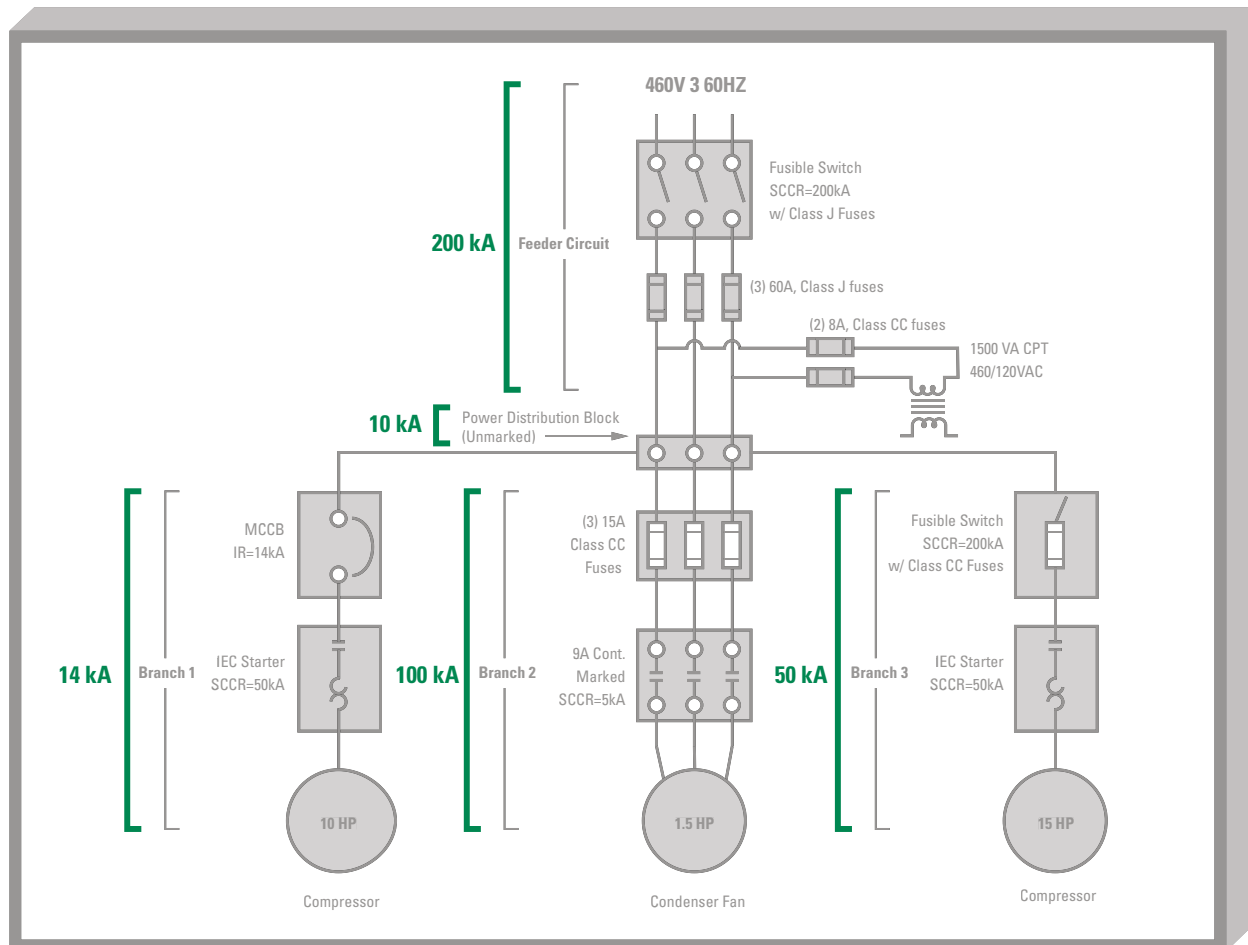
In the example shown in Figure 6, all power components in the power feeder circuit and branch circuits are marked with an SCCR or Interrupting Rating except for the power distribution block that distributes the power within the panel. According to Table SB4.1 of UL 508A Supplement SB, the default short circuit current for unmarked terminal blocks or power distribution blocks is 10 kA.

After recording the SCCR of each power component in the panel and assigning SCCRs to unmarked components from Table SB4.1, it first appears that the contactor in branch circuit #2 with a marked SCCR of 5 kA is the lowest rated SCCR in the panel. However, certain combinations of power components with overcurrent protective devices, such as motor controllers with current-limiting fuses may be UL certified and approved with a series rated SCCR that is higher than the lowest rated SCCR of any individual component. If any combination within the control panel has been

UL certified and Listed as such, then the SCCR of the approved series combination can be considered when establishing the weakest link of a branch circuit. In this example, after consulting with the manufacturer of the contactor used in branch circuit #2, and with its UL listing documents, we learn that when the contactor is protected in series by UL Class CC or UL Class J fuses, it is UL approved for "type 2" coordination with a series rated SCCR of 100 kA. This combination series rating not only increases the SCCR of the branch circuit, but also provides the assurance that the contactor will remain operable after a short circuit. Always consult equipment manufacturers to verify UL approved series combination short circuit current ratings and special circumstances that can increase the SCCR of your panel.

If we were to take our panel diagram from Figure 6 and add the SCCR of each component, approved series combinations, and feeder and branch circuits, it would look something like Figure 8.:

Figure 8





At the completion of Step 1:

- The SCCR of the Feeder Circuit is 200 kA
- The minimum SCCR of Branch Circuit #1 is 14 kA due to the IR of the MCCB
- The SCCR of Branch Circuit #2 is 100 kA because of the approved series combination rating.
- The minimum SCCR of Branch Circuit #3 is 50 kA due to the IEC starter.
- And the lowest rated SCCR in the panel is the power distribution block, with a SCCR of 10 kA from Table SB4.1

Step 2

Modify the SCCR of certain component combinations if current-limiting fuses are used in the feeder circuit.

UL 508A Supplement SB Article SB4.3 describes how feeder components such as current-limiting fuses can limit the available short circuit current within the panel. Table SB4.2² of UL 508A Supplement SB (See Figure 9) is a listing of the UL maximum allowable instantaneous peak let through current (I_{peak}), and the maximum allowable clearing I^2t for UL Class current-limiting fuses at different levels of prospective available RMS fault

Figure 9: UL maximum allowable peak let-through current (I_{peak}) for current-limiting fuses at 600 VAC and at various available fault currents².

Table SB4.2²
PEAK LET THROUGH CURRENTS, I_p , AND CLEARING, I^2t , FOR FUSES

Table SB4.2 effective April 25, 2006

Fuse types	Fuse rating amps	Between threshold and 50 kA		100 kA		200 kA							
		$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$						
Class CC	15	2	3	2	3	3	4						
	20	2	3	3	4	3	5						
	30	7	6	7	7.5	7	12						
Glass G	15	-	-	3.8	4	-	-						
	20	-	-	5	5	-	-						
	30	-	-	7	7	-	-						
	60	-	-	25	10.5	-	-						
300 volt Class T	30	3.5	5	3.5	7	3.5	9						
	60	15	7	15	9	15	12						
	100	40	9	40	12	40	12						
	200	150	13	150	16	150	20						
	400	500	22	550	28	550	35						
	600	1000	29	1000	37	1000	46						
	800	1500	37	1500	50	1500	65						
1200	3500	50	3500	65	4000	80							
Class J and 600 V Class T	30	7	6	7	7.5	7	12						
	60	30	8	30	10	30	16						
	100	60	12	80	14	80	20						
	200	200	16	300	20	300	30						
	400	1000	25	1100	30	1100	45						
	600	2500	35	2500	45	2500	70						
800	4000	50	4000	55	4000	75							
Class L	800	10000	80	10000	80	10000	80						
	1200	12000	80	12000	80	15000	120						
	1600	22000	100	22000	100	30000	150						
	2000	35000	110	35000	120	40000	165						
	2500	-	-	75000	165	75000	180						
	3000	-	-	100000	175	100000	200						
	4000	-	-	150000	220	150000	250						
	5000	-	-	350000	-	350000	300						
	6000	-	-	350000	-	500000	350						
Class R		RK1	RK5	RK1	RK5	RK1	RK5	RK1	RK5	RK1	RK5	RK1	RK5
	30	10	50	6	11	10	50	10	11	11	50	12	14
	60	200	200	10	20	40	200	12	21	50	200	16	26
	100	500	500	14	22	100	500	16	25	100	500	20	32
	200	1600	1600	18	32	400	1600	22	40	400	2000	30	50
	400	5000	5000	33	50	1200	5000	35	60	1600	6000	50	75
	600	10000	10000	43	65	3000	10000	50	80	4000	12000	70	100

^a Value applies to Class T fuses.



current (200 kA, 100 kA, or 50 kA). All manufacturers of UL approved current-limiting fuses must limit the I_{peak} and I^2t to the maximum values shown in this table. UL 508A Supplement SB uses the I_{peak} values listed in Table SB4.2 to determine the fuse's ability to limit the peak let-through current to branch circuits within the panel.

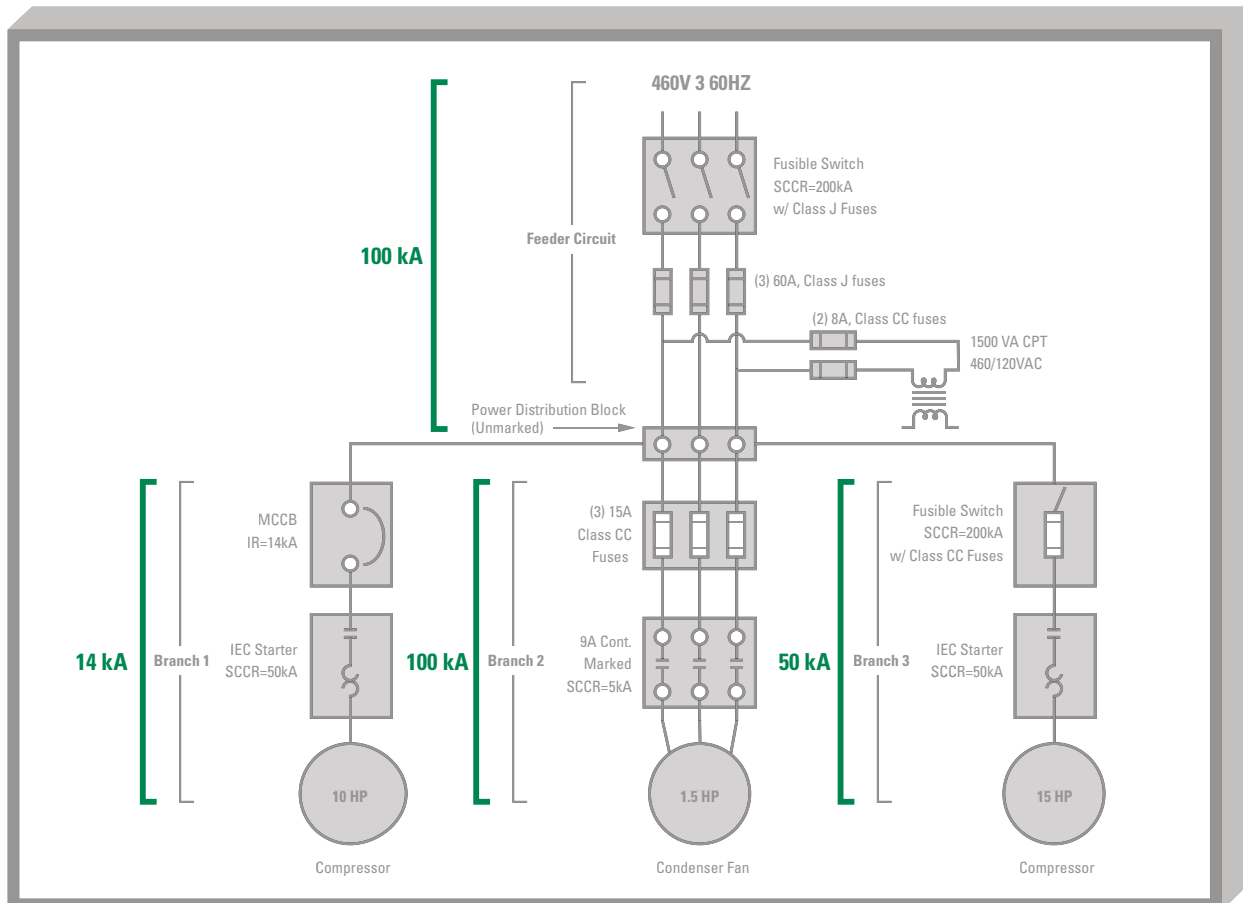
To determine the SCCR of a series combination within the panel, UL 508A Article SB 4.3.3 states that if the I_{peak} of the feeder fuse is less than or equal to the lowest SCCR of any passive component in a branch circuit, then the SCCR of the combination is the available RMS current of the fuse. The following example should help explain this.

Figure 8 shows that the Power Distribution Block with an assumed SCCR of 10 kA is directly in series with the UL Class J current-limiting feeder circuit fuse rated 60 amps. Table SB4.2 shows that the maximum allowable I_{peak} of the 60 ampere Class J fuse at an available RMS fault current of 200 kA is 16 kA. This value exceeds the SCCR of the power distribution

block (10 kA). However, Table SB4.2 shows that the maximum allowable I_{peak} of the same fuse at an available RMS fault current of 100 kA is 10 kA, which is less than or equal to the power distribution block SCCR of 10 kA. Therefore, the SCCR of the series combination is 100kA. This process may be repeated with power components in all branch circuits to determine if the current-limiting fuse may increase the SCCR of other combinations.

It is important to point out that Step 2 modifications apply only to current-limiting devices in the feeder circuit with passive (non-overcurrent) protective devices in branch circuits. In this example, based on Table SB4.2, the 60 Ampere UL Class J fuse in the feeder circuit is able to limit the I_{peak} to 10 kA or less if the available fault current were 100 kA. However, if the actual fault current is less than 100 kA, but greater than the interrupting rating of the branch circuit overcurrent protective device, the branch circuit overcurrent device may open at the same time the feeder fuse begins to clear the circuit, possibly causing a hazardous situation. Therefore, the SCCR of the

Figure 10



panel cannot be greater than the lowest Interrupting Rating of any fuse or circuit breaker in the panel, unless it is tested and listed by a NRTL.

After performing step 2, we now have the configuration illustrated in Figure 10:

- The SCCR of the Feeder Circuit and power distribution block is 100 kA
- The minimum SCCR of Branch Circuit #1 is 14 kA due to the MCCB
- The SCCR of Branch Circuit #2 is 100 kA
- The minimum SCCR of Branch Circuit #3 is 50 kA due to the IEC starter

It is important to note that presently, UL 508A Table SB4.2 does not list the UL maximum allowable instantaneous peak let through currents for all UL fuse current ratings, such as Class J fuses rated less than 30 Amps, or 600 volt Class T fuses greater than 800 Amperes. In the next edition of UL 508A, UL may add other fuse values to Table SB4.2 or possibly allow the use of manufacturers' published peak let through curves to determine the I_{peak} of specific fuse types and ratings. Please contact UL for the latest edition of UL 508A Supplement SB and for fuse values not shown in Figure 9.

Control circuit overcurrent protection

UL 508A Article SB3.2 requires branch circuit overcurrent protection for control circuits that are tapped off the feeder circuit as shown in Figure 6. Furthermore, the Interrupting Rating of the branch circuit fuse or circuit breaker must be equal to or greater than the overall SCCR of the panel. In the example given above, the 8 Ampere control circuit fuses are branch circuit UL Class CC fuses with a marked IR of 200 kA, complying with this requirement. It is important to remember that supplementary fuses or supplementary protectors are not allowed on the primary side of control circuits. The SCCR of the panel can be no greater than the IR of the branch circuit rated control circuit fuse or circuit breaker.

Step 3

Apply the lowest rated SCCR of any power component, overcurrent protective device, or modified combination to the SCCR of the panel.

In our example, after modifying the SCCR of certain combinations based on the I_{peak} of the current-limiting feeder fuse, the SCCR of the panel is based on the lowest rated SCCR of any power component

not modified by Step 2, the lowest rated SCCR in any branch circuit, or the lowest rated SCCR of any overcurrent protective device.

Since Branch Circuit #1 contains the lowest rated SCCR of 14 kA based on the interrupting rating of the Molded Case Circuit Breaker, the SCCR of the entire panel is 14 kA. Figure 11 shows an equipment label marked with the corresponding SCCR.

Figure 11



How to increase the SCCR of industrial control panels

In the example above, we see that selecting properly rated components and protective devices can affect the SCCR of your assembly. There are several things that you can do to increase the SCCR and reliability of your industrial control panels while also increasing the safety of electrical workers.

- Use components or approved combinations with higher SCCRs.
- Use current-limiting fuses or other current-limiting components in the feeder circuit (refer to UL 508A Supplement SB for more information)
- Use overcurrent protective devices with higher interrupting ratings in branch and control circuits.
- Submit the panel to UL or another NRTL for approval testing utilizing the "Tested Method."

Let us look again at Figure 6. One easy way to increase the SCCR of this panel would be to replace the 14 kA MCCB in Branch Circuit #1 with a fusible disconnect switch. For example, replacing the MCCB



with a Littelfuse type LFFS030CC disconnect switch with Littelfuse Class CC fuses would increase the minimum SCCR of Branch Circuit #1 to 50 kA. Therefore, the SCCR of the entire panel would be increased to 50 kA.

It is also important to keep in mind that UL 508A Supplement SB assigns a maximum SCCR of only 200 amperes to unmarked supplementary protectors (see Figure 7). UL 508A Article SB3.2 does not allow supplementary protectors in the primary of control circuits. If any supplementary protectors are used in branch circuits, simply replacing the supplementary protector with Littelfuse UL Class CC fuses dramatically increase the SCCR of an industrial control panel.

Littelfuse, Inc. has recently announced that its LD and LS Power Distribution Blocks and Splicer Blocks are now UL Listed with higher SCCRs that can increase the SCCR of your industrial control panel.

Please refer to our SCCR Center website at www.littelfuse.com/SCCR for more information.

Summary

- All industrial control panels must be marked with a SCCR
- Panels can be submitted and tested by a NRTL to establish the SCCR
- UL 508A Supplement SB can be used to establish the SCCR
- Using current-limiting fuses is the best and easiest way to increase the SCCR of your panel.
- Current-limiting fuses increase safety and reliability.

It is important to remember that if a panel is UL Listed and Labeled, or if UL 508A Supplement SB is used to establish the high fault SCCR of the panel, all components and ratings must be thoroughly examined and documented. In order to maintain the marked SCCR, warning labels and instructions must clearly indicate the requirement to replace overcurrent protective devices only with the specific components originally designed for use in this application.

Following NEC and UL 508A standards and regulations will assure manufacturers and users that their systems meet national and local installation codes and standards, are highly reliable, and are safe for workers to use and maintain.

Littelfuse, Inc. offers a complete line of current-limiting fuses and accessories to increase the SCCR of industrial control panels and reduce Arc-Flash Hazards for electrical workers. Littelfuse POWR-GARD Services also provides SCCR consultation services, Arc-Flash Hazard Assessments, and other services that help manufacturers, building owners and managers meet all applicable OSHA and NFPA safety regulations and guidelines.

For more information about NEC 409, UL 508A and products that can help increase the SCCR and safety of your industrial control panels, please contact Littelfuse Electrical Products Technical Support at 1-800-TEC-FUSE, or visit us at www.littelfuse.com.



Endnotes

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