Bussmann®

Productivity Through Protection™

Update on 2005 Code Changes

COOPER Bussmann

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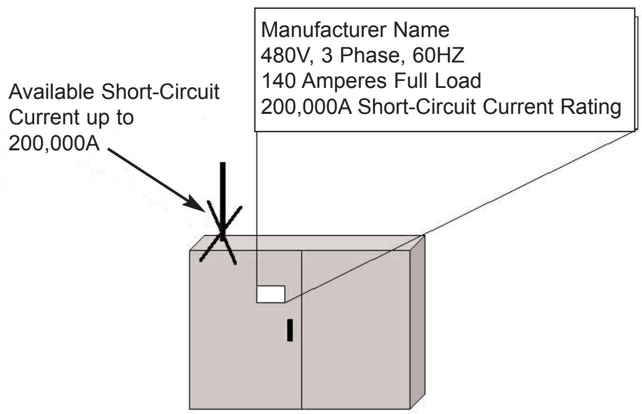
Marking Short-Circuit Current Ratings Now Required

Equipment Protected by Current Limiting Fuses Can Achieve High Short-Circuit Current Ratings



Industrial Control Panel

Background

The 2005 NEC® has new requirements for certain equipment and motor controllers to be marked with their short-circuit current rating. This facilitates the inspection and approval process. Inspectors need this information to ensure that 110.10 is met. The potential hazard exists where higher fault currents are available.

It is now required that industrial control panels, industrial machinery electrical panels, certain HVAC equipment, motor controllers and certain meter disconnects be marked with their short-circuit current rating. The next page provides the new NEC® sections. There are exceptions.

Short-circuit current ratings marked on components and equipment make it easier to verify proper protection for components and equipment for specific applications whether it be the initial installation or relocation of equipment. For proper protection and compliance with NEC® 110.10, the short-circuit current rating for a component or equipment shall be equal to or greater than the available short-circuit current where the equipment is being installed in the system.

Ensuring Compliance

For the affected types of equipment, simply require the following:

1. For the plan review process, the engineer supplies the available short-circuit current at each equipment installation point and the specific short-circuit current rating for each piece of equipment or industrial control panel.
2. Upon site inspection, compare the actual equipment marked short-circuit current rating to the submitted data to ensure the rating is indeed as specified and sufficient for the available short-circuit current available at the point of installation.

Another simpler method if all the equipment has high short-circuit current ratings:

1. Verify the maximum, worst case short-circuit current available at the terminals of the supply transformer.
2. If all the equipment in the system has short-circuit current ratings greater than this maximum, worst case available short-circuit current, then the detailed short-circuit current study is not necessary. Equipment properly protected by current-limiting fuses can easily achieve short-circuit current ratings of 100,000A or 200,000A.

New Requirements

Air Conditioning and Refrigeration Equipment with Multimotor and Combination-Loads
440.4(B) requires the nameplate of this equipment to be marked with its short-circuit current rating. There are exceptions for which this requirement does not apply to this equipment:

- one and two family dwellings,
- cord and attachment-plug connected equipment,
- or equipment on a 60A or less branch circuit.

So for most commercial and industrial applications, air conditioning and refrigeration equipment with multimotor and combination loads must have the short-circuit current rating marked on the nameplate.

Industrial Control Panels
Article 409 Industrial Control Panels is a new article as of the 2005 NEC®. 409.110 requires that an industrial control panel be marked with its short-circuit current rating.

Industrial Machinery Electrical Panel
670.3(A) requires the industrial control panel nameplate of industrial machinery to include its short-circuit current rating. In the past, the NEC® required that the machine nameplate include only the interrupting rating of the machine overcurrent protective device, if one was furnished. This marking could be misleading as it did not

represent the short-circuit current rating of the entire machine, but could be mis-interpreted as such.

Meter Disconnect Switches (rated up to 600V)
230.82(3) permits a meter disconnect switch ahead of the service disconnecting means, provided the meter disconnect switch has a short-circuit current rating adequate for the available short-circuit current.

Motor Controllers
Component Marking – **430.8** now requires that motor controllers be marked with their short-circuit current rating. There are some exceptions.

Easiest Way To Achieve High Short-Circuit Current Ratings

Equipment and controllers with higher short-circuit current ratings will be more attractive and easier to specify, install, and meet compliance. Plus when equipment is moved to another location, as is often done with industrial machinery, high short-circuit current ratings ensure safer installations. Protection with current limiting fuses is the easiest and most effective way to achieve higher short-circuit current ratings.

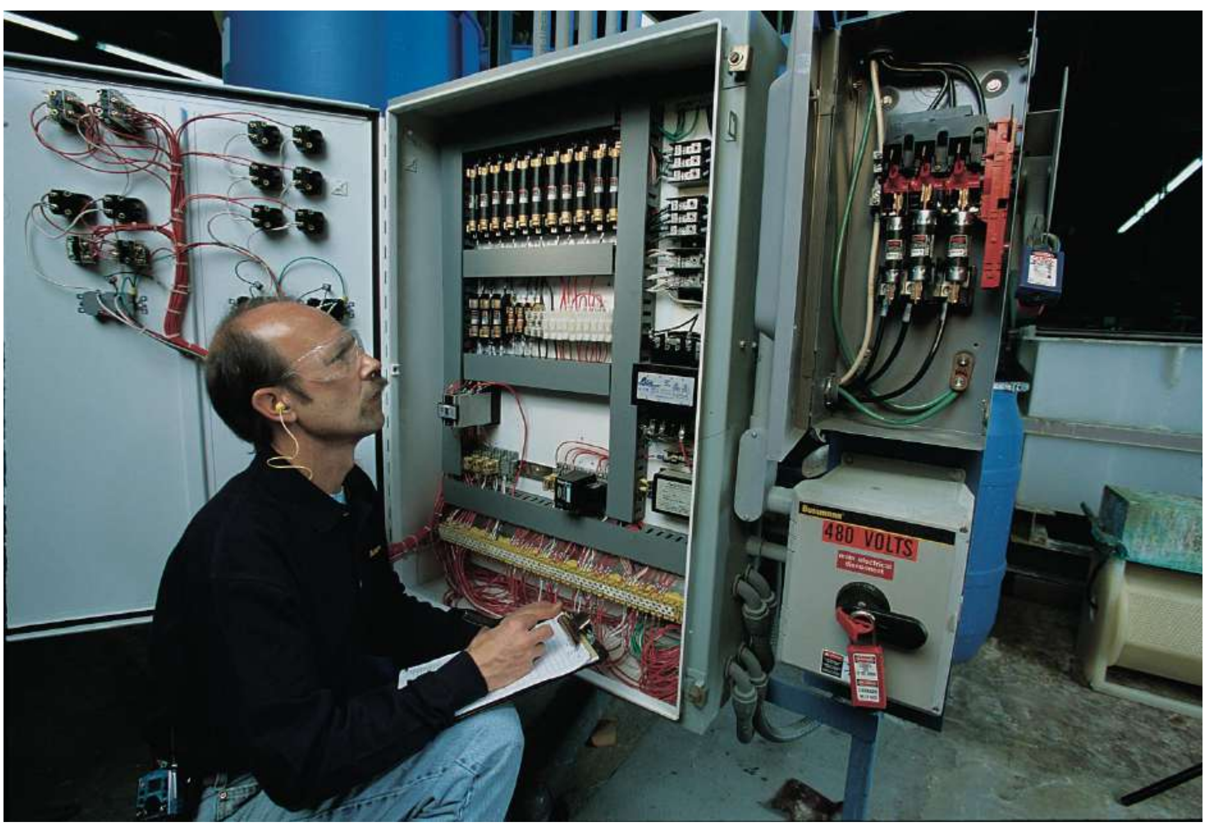
A motor controller illustrates this point very well. The Bussmann® compact, non-fused disconnect, the CDNF63, is a Listed UL 508 Manual Motor Controller with a maximum horsepower rating of 40hp at 480V. It is marked with a short-circuit current rating of 5kA when protected by up to a 150A Class H fuse. However, the short-circuit current rating for the CDNF63 is marked 100kA when protected with up to a Bussmann® LPJ-100SP fuse (100A Class J) or JJS-100 fuse (100A Class T).

What is Short-Circuit Current Rating?

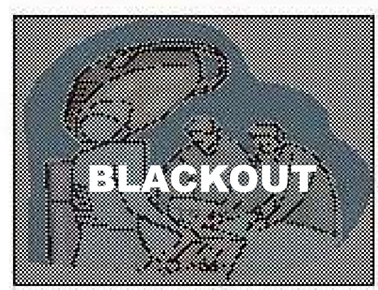
"Short-circuit current rating" is **not** the same as interrupting rating and the two must not be confused.

Interrupting rating is the maximum short-circuit current a fuse or circuit breaker can safely interrupt under standard test conditions; it does not ensure protection of the circuit components or equipment. Adequate interrupting rating is required per NEC® 110.9

Short-circuit current rating is the maximum short-circuit current a component or equipment can safely withstand when protected by a specific overcurrent protective device or for a specified time. Adequate short-circuit current rating is required per NEC® 110.10.



Selective Coordination Now Required For Emergency Systems, Legally Required Standby Systems, and Essential Electrical Systems in Health Care Facilities



Background

Selective coordination is now required for increased system reliability, which is vital for these critical systems. **Selective coordination** can be defined as isolating an overloaded or faulted circuit from the remainder of the electrical system by having **only** the nearest upstream overcurrent protective device open. The following was added to NEC® 2005

> **Article 100 Definitions: Coordination (Selective).** *Localization of an overcurrent condition to restrict outages to the circuit or equipment affected, accomplished by the choice of overcurrent protective devices and their ratings or settings.*

The one-line diagrams in Figure 1 and Figure 2 demonstrate the concept of selective coordination.

Selective coordination is an important new NEC® 2005 requirement that is consistent with the critical need to keep these loads powered even with the loss of normal power. **Article 700, Emergency Systems,** and **Article 701, Legally Required Standby Systems** have several requirements that are based upon providing a system with reliable operation, reduction in the probability of faults and minimizing the effects of an outage to the smallest portion of the system as possible. **Article 517, Health Care Facilities,** requires **essential electrical systems** to meet the requirements of Article 700 except as amended in Article 517. The objective of these requirements is to ensure system uptime with the goal of safety of human life during emergencies or for essential health care functions. Selective coordination of overcurrent devices fits well with the other requirements such as:

- **700.4** maintenance and testing requirements
- **700.9(B)** emergency circuits separated from normal supply circuits
- **700.9(C)** wiring specifically located to minimize system hazards
- **700.16** failure of one component must not result in a condition where a means of egress will be in total darkness

Ensuring Compliance

Achieving the proper overcurrent protective device selective coordination requires proper engineering, specification and installation of the required devices.

During the plan review process, it is the design engineer's responsibility to provide documentation that verifies the overcurrent devices are selectively coordinated for the full range of overcurrents that can occur in the system. And the site inspection should verify the overcurrent protective devices are installed as specified to achieve selective coordination.

It is possible for both fusible and circuit breaker systems to be selectively coordinated with proper analysis and selection. Selective coordination is easy with Bussmann® fuses by using the published fuse selective coordination ratios; a full short-circuit and coordination study is not necessary to verify selective coordination. Selective coordination with circuit breakers depends on their characteristics and settings as well as the circuit parameters for the specific application. It is generally difficult to achieve selective coordination with common circuit breakers that incorporate instantaneous trip settings. Typically circuit breakers with short-time delay settings or zone selective interlock features may be necessary, which can add to the cost and may create other system issues. If using **zone selective interlocking options**, molded case and insulated case circuit breakers **still have an instantaneous trip that overrides the zone selective tripping feature**. This is necessary to protect the circuit breaker from severe damage. Consequently blackouts can occur even with this zone selective interlocking feature. If circuit breakers are to be considered, a full short-circuit current and coordination study must be done with proper analysis and interpretation. See simple fuse and circuit breaker examples are on page 8.

Example (See Figures 1 & 2)

If overcurrent protective devices in the emergency system are not selectively coordinated, a fault at X_1 on the branch circuit may unnecessarily open the sub-feeder; or even worse the feeder or possibly even the main. In this case, emergency circuits are unnecessarily blacked out. With selective coordination as a requirement for emergency, legally required standby, and essential electrical systems, when a fault occurs at X_1 only the nearest upstream fuse or circuit breaker supplying just that circuit would open. Other emergency loads would remain powered.

New Requirements

2005 NEC®
700.27 Coordination. *Emergency system(s) overcurrent devices shall be selectively coordinated with all supply side overcurrent protective devices.*

701.18. Coordination. *Legally required standby system(s) overcurrent devices shall be selectively coordinated with all supply side overcurrent protective devices.*

517.26 Application of Other Articles. *The essential electrical system shall meet the requirements of Article 700, except as amended by Article 517.*

Notes:
1. Article 517 has no amendment to the selective coordination requirement, therefore selective coordination is required.
2. Selective coordination is required for both the normal supply path and the emergency system path.

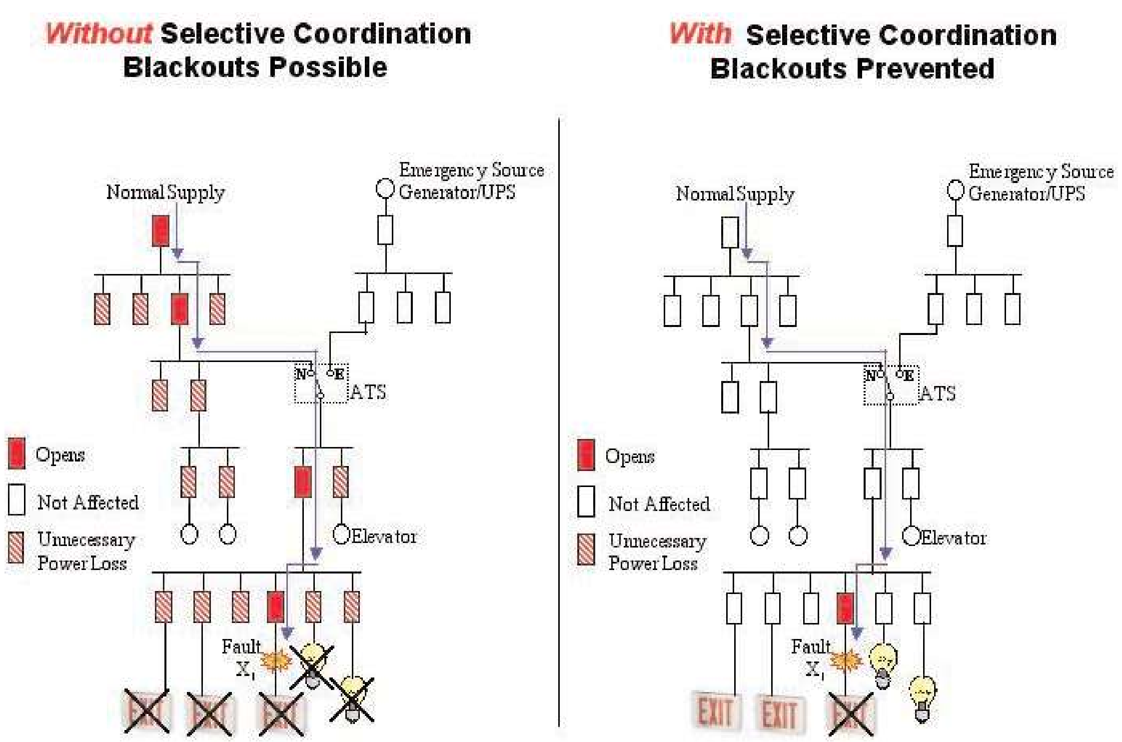


Figure 1 - Normal Source Power to Emergency Circuits

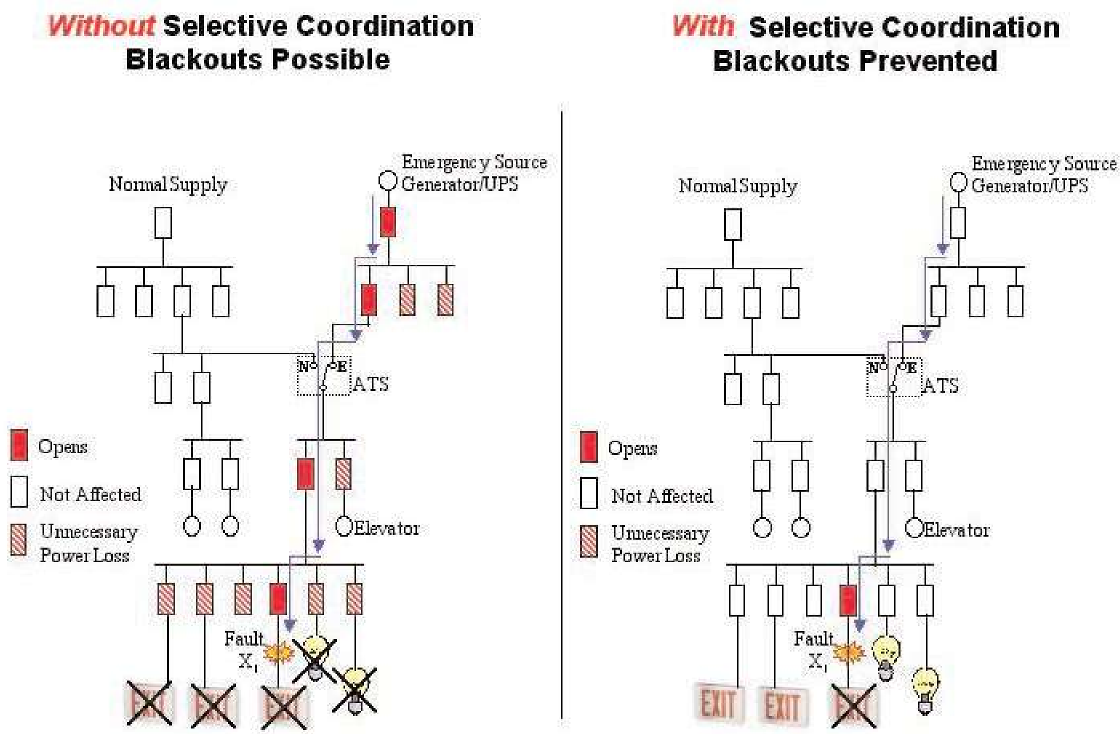
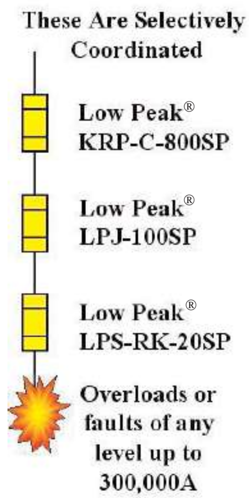


Figure 2 - Emergency Service Power to Emergency Circuits

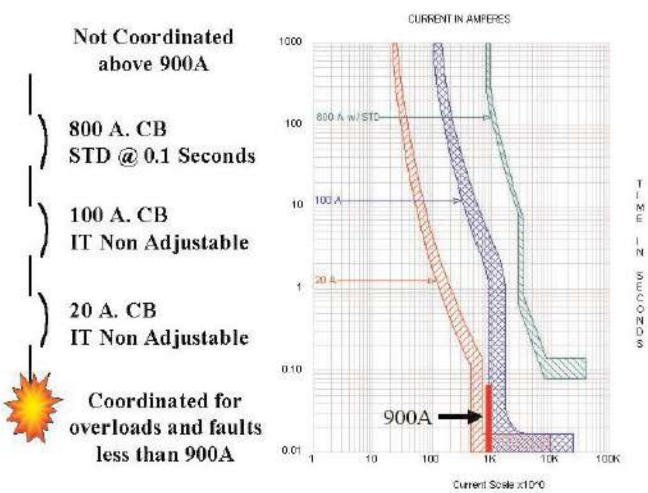
The Cooper Bussmann **SPD Selecting Protective Devices** publication has an in-depth discussion on selective coordination analysis with the published fuse selectivity ratios, some simple evaluation rules for coordination of instantaneous trip circuit breakers, and illustration of short-time delay circuit breakers.

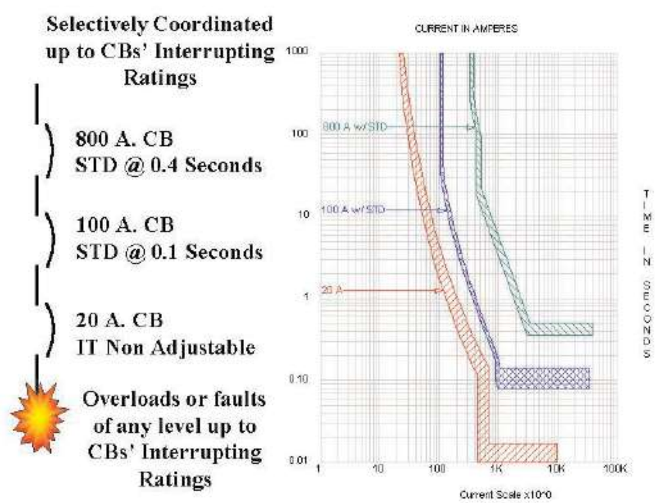


Lineside Fuse	Loadside Fuse: KRP-C_SP	LPJ_SP	LPS-RK_SP
KRP-C_SP	2:1	2:1	2:1
LPJ_SP	-	2:1	2:1
LPS-RK_SP	-	2:1	2:1

Lineside KRP-C-800SP to Loadside LPJ-100SP
800/100=**8:1** Table shows only 2:1 needed
Therefore Selective Coordination achieved

Lineside LPJ-1000SP to Loadside LPS-RK-20SP
100/20=5:1 Table shows only 2:1 needed
Therefore Selective Coordination achieved





1. *If circuit breakers are not maintained, extended clearing times or nuisance operation may compromise coordination.*
2. *If using zone selective interlocking option, molded case and insulated case circuit breakers still have an instantaneous trip that overrides the zone selective tripping feature. Blackouts still can occur since selective coordination can not be achieved.*

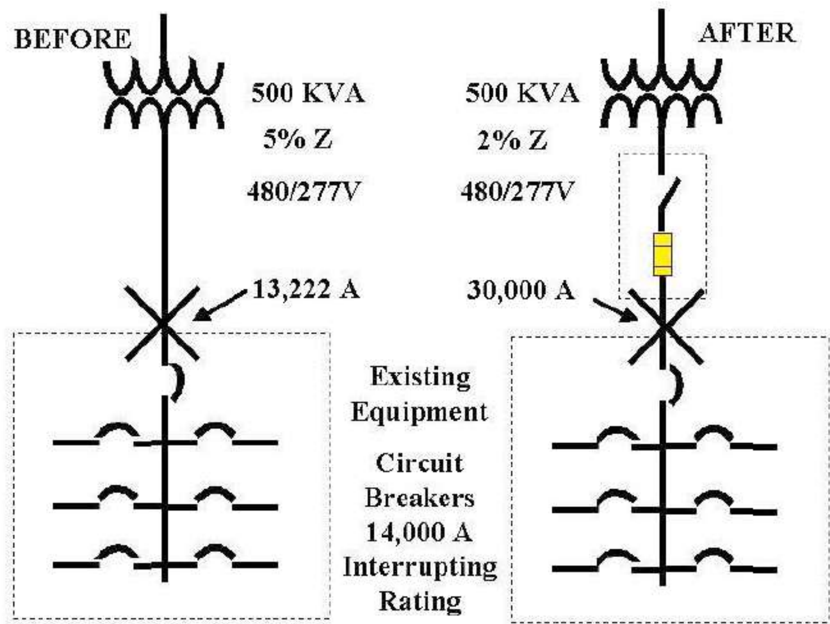
Other Information

Emergency systems are considered in places of assembly where artificial illumination is required and for areas where panic control is needed such as hotels, theaters, sports arenas, health care facilities, and similar institutions. Emergency systems also provide power to functions for ventilation, fire detection and alarm systems, elevators, fire pumps, public safety communications, or industrial processes where interruption could cause severe human safety hazards.

Legally required standby systems are intended to supply power to selected loads in the event of failure of the normal source. Legally required standby systems typically serve loads in heating and refrigeration, communication systems, ventilation and smoke removal systems, sewage disposal, lighting systems, and industrial processes where interruption could cause severe human safety hazards.

Essential electrical systems in healthcare facilities are portions of the electrical system designed to ensure continuity of lighting and power to designated areas/functions during normal source power disruptions or disruptions within the internal wiring system. Essential electrical systems can include the critical branch, life safety branch, and equipment systems which are essential for life safety and orderly cessation of procedures during normal power disruptions.

240.86(A) Series Ratings in Existing Facilities



Background

The new **240.86(A)** permits selection of series ratings for existing systems when the selection is made by a licensed professional engineer. When buildings undergo improvements or if new transformers are installed, quite often the new available short circuit-current exceeds the existing circuit breakers' interrupting rating. This is a serious safety hazard and does not comply with NEC® 110.9. Prior to the 2005 NEC®, under this condition, about the only option an owner had was to remove and scrap the existing circuit breaker panel and install a new circuit breaker or fusible switch panel that has overcurrent protective devices that are sufficient for the new available short-circuit current. This is very expensive and disruptive.

Now for existing systems, a licensed professional engineer can determine if an upgrade of lineside fuses or circuit breakers can series rate with existing loadside circuit breakers. This new option may save an owner significant money and provide a safer system than if no action is taken when the available short-circuit current exceeds the installed circuit breakers' interrupting rating.

For new installations, the process remains the same as the 2002 NEC®: the series rated combinations shall be tested, listed and marked for use with specific panel boards and switchboards.

Ensuring Compliance

Require the engineer to provide the necessary analysis that insertion of a set of lineside fuses or circuit breaker can provide protection to the downstream circuit breakers. The documentation for the selection of series ratings for existing systems shall be stamped by the engineer and be readily available to those involved in the design, installation, inspection, maintenance and operation of the equipment installation.

New Requirement

> **2005 NEC®**
> **240.86 Series Ratings.** *Where a circuit breaker is used on a circuit having an available fault current higher then the marked interrupting rating by being connected on the load side of an acceptable overcurrent protective device having a higher rating, the circuit breaker shall meet the requirements specified in (A) or (B), and (C).*
>
> **(A) Selected Under Engineering Supervision in Existing Installations.** *The series rated combination devices shall be selected by a licensed professional engineer engaged primarily in the design or maintenance of electrical installations. The selection shall be documented and stamped by the professional engineer. This documentation shall be available to those authorized to design, install, inspect, maintain, and operate the system. This series combination rating, including identification of the upstream device, shall be field marked on the end use equipment.*
>
> **(B) Tested Combinations.** *The combination of line-side overcurrent device and load-side circuit breaker(s) is tested and marked on the end use equipment, such as switchboards and panelboards.*
>
> **(C) 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 interrupt rating of the lower-rated circuit breaker.*

Methods To Series Rate Existing Systems

There may be several analysis options for a licensed professional engineer to rectify the situations where existing circuit breakers have inadequate interrupting ratings. In some cases, a suitable method may not be feasible. New methods may surface in the future.
Some methods:

1. Check to see if a new fused disconnect can be installed ahead of the existing circuit breakers by using a listed series rated combination. Even though the existing system may not take advantage of series ratings, if the existing circuit breakers are not too old, the panel may have a table or booklet that provides all the possible listed combinations of fuse-circuit breaker series ratings.
2. If the existing system used series ratings with Class R fuses, analyze whether a specific Bussmann® Class RK1, J or T fuse may provide the protection at the higher short-circuit current. The series ratings for panelboards that use lineside Class R fuses have been determined with special, commercially unavailable Class RK5 umbrella fuses (Commercially unavailable umbrella fuses are only sold to electrical equipment manufacturers in order to perform equipment short-circuit testing) Actual, commercially available Bussmann® Class RK1, J or T fuses will have current-limiting let-through characteristics considerably less than the Class RK5 umbrella limits.
3. Supervise short circuit testing of lineside current-limiting fuses to verify that protection is provided to circuit breakers that are identical to the installed, existing circuit breakers.
4. Perform an analysis to determine if a set of current-limiting fuses installed on the lineside of the existing circuit breakers provides adequate protection for the circuit breakers. For instance, if the existing equipment is low voltage power circuit breakers (approximately three cycle opening time), then the line-side fuse short-circuit let-through current (up, over, and down method) must be less than the circuit breaker's interrupting rating. An appropriate analysis method has yet to be found for circuit breakers that clear in less than a 1/2 cycle. It is possible, but a practical analysis method based on present available circuit breaker data is not yet feasible

Suggestion for New Installations

Use Bussmann® Low-Peak® Fuses throughout system for a fully rated system:

1. The owner does not have to unexpectedly make significant changes to the electrical system because the short-circuit current increased after the initial installation. KRP-C_SP, LPJ_SP, LPN-RK_SP, and LPS-RK_SP Low-Peak® fuses have interrupting ratings of 300,000A. This is adequate for all but a few installations in the world.
2. The owner does not have to have required periodic maintenance and testing performed on fuses to ensure their ability to operate as intended.

Note

A new **"240.93 Series Ratings,"** is shown in the first printing of the 2005 NEC®. **It appears that this is a misprint and will be removed** from future editions. The requirements of 240.86 apply to Part VIII. Supervised Industrial Installations. There are no special requirements or allowances in 240.93 for series ratings for Supervised Industrial Installations.

100 Definition: Supplementary Overcurrent Protective Device

A definition for Supplementary overcurrent protective device has been added to Article 100. This definition has been added to help avoid serious misapplication of devices that have not been tested for general purpose usage. Supplementary overcurrent protective devices must not be applied where branch circuit overcurrent protective devices are required; unfortunately this unsafe misapplication is prevalent in the industry.

New Definition

2005 NEC®
Supplementary Overcurrent Protective Device. A device intended to provide limited overcurrent protection for specific applications and utilization equipment such as luminaires (lighting fixtures) and appliances. This limited protection is in addition to the protection provided in the required branch circuit by the branch circuit overcurrent protective device.

Supplementary overcurrent protective devices are not general use devices, as are branch circuit devices, and must be evaluated for appropriate application in every instance where they are used. Supplementary overcurrent protective devices are extremely application oriented and prior to applying the devices, the differences and limitations for these devices must be investigated and found acceptable.

Examples of supplemental overcurrent protective devices include, but are not limited to the following:

UL248-14
Supplemental Fuses

UL1077 Supplemental
Protectors (Mini Circuit Breakers)

One example of the difference and limitations is that a supplementary overcurrent protective device may have spacings, creepage and clearance, that are considerably less than that of a branch circuit overcurrent protective device.
Example:
• A supplemental protector, UL1077, has spacings that are 3/8 inch through air and 1/2 inch over surface at 480V.
• A branch circuit rated UL489 molded case circuit breaker has spacings that are 1 inch through air and 2 inches over surface at 480V.

Another example of differences and limitations is that branch circuit overcurrent protective devices have standard overload characteristics to protect branch circuit and feeder conductors. Supplementary overcurrent protective devices do not have standard overload characteristics and may differ from the standard branch circuit overload characteristics. Also, supplementary overcurrent protective devices have interrupting ratings that can range from 32 amps to 100,000 amps. When supplementary overcurrent protective devices are considered for proper use, it is important to be sure that the device's interrupting rating equals or exceeds the available short-circuit current and that the device has the proper voltage rating for the installation (including compliance with slash voltage rating requirements, if applicable).

Reasons Why Supplemental Protectors (UL1077 Devices) can not be used to Provide Branch Circuit Protection

1. Supplemental Protectors are not intended to be used or evaluated for branch circuit protection in UL1077
2. Supplemental protectors have drastically reduced spacings, compared to branch circuit protective devices, which depend upon the aid of a separate branch circuit protective device upstream
3. Supplemental protectors do not have standard calibration limits or overload characteristics performance levels and cannot assure proper protection of branch circuits
4. Multipole supplemental protectors for use in 3 phase systems are not evaluated for protection against all types of overcurrents
5. Most supplemental protectors are tested with a branch circuit overcurrent device ahead of them and rely upon this device for proper performance
6. Supplemental protectors are not required to be tested for closing into a fault
7. Recalibration of a supplemental protector is not required and depends upon manufacturer’s preference. There is no assurance of performance following a fault or resettability of the device.
8. Considerable damage to a supplemental protector is allowed following short circuit testing.
9. Supplemental protectors are not intended to:
   • Provide Branch Circuit Protection
   • Be used as a Disconnecting Means
10. Supplemental protectors are not evaluated for short circuit performance criteria, such as energy let through limits or protection of test circuit conductors

240.5(B) Protection of Flexible Cords, Flexible Cables, and Fixture Wires

Prior to the 2005 NEC® the supply cords of listed appliances, portable lamps, and listed extension cord sets were "assumed" to be protected by the branch circuit overcurrent protective device. There has been a change to the 2005 NEC® that removes this assumption. The new requirement considers these cords to be protected when applied within the listing requirements.

There has been a lot of focus on preventing fires due to arcing faults in recent code cycles. This focus has brought about the requirements for AFCI protection on bedroom circuits. Many of the studies that were used to substantiate the AFCI requirement show that as many as 60% of all electrical fires started on the load side of the outlet. The fires start in the extension cords, supply cords, and appliances. This new requirement places the responsibility on the cord/equipment manufacturers and product safety standards to evaluate the protection of the appliances and cords, and any possible necessity for supplemental overcurrent protection.

Nationally Recognized Testing Laboratories (NRTLs) and the equipment manufacturers will now have to determine if the small wire is properly protected. Some equipment that has never caused fires will not be affected. But other equipment that has a poor record for causing fires will likely be required to provide the protection of their cords. That protection might come in the form of supplementary fuses, AFCIs, GFCIs, or a combination of two or more of these.

Fused line cords are one of the possible and least costly solutions for equipment that may cause a fire. This is currently a common practice for holiday lights. This method is also widely used in the UK and Japan.

In addition Cooper Bussmann provides a specialty fuse targeted specifically for electric cord applications. The ECF fuse (electric cord fuse) is an integral fuse and cord-plug blade. The cord-plug blade is stamped "fuse" and is non-polarized ("hot"). The fuse ampere rating is stamped on the fuse ferrule. Appliance manufacturers and plug/cord manufacturers can incorporate the ECF fuse into their plug design. This is a simple, reliable, low cost means to protect cords and appliances.

The presently available ampere ratings range from 1/2A to 5A. For high volume applications requiring amperage ratings outside this range, please contact Cooper Bussmann sales or representatives.

Some of the features of this concept:

- Dual protection: can protect the power cord and appliance against overcurrents
- Superior fault protection: ECF fuses can be sized properly and are fast acting on short-circuits
- No-space protection: no additional space is needed to get the necessary protection
- Supplementary fusing feasible: this makes it practical to provide line cord fusing
- Cost effective: no additional fuseholder or blocks within the housing of the product
- Easy replacement: push, twist, and pull out and then the reverse action to install. Can be designed so that the ECF fuse securely locks in with a positive-hold spring lock
- Fuse replacement is shock proof: the cord plug must be removed from the outlet receptacle to replace the ECF fuse
- Size rejecting: ECF fuses are designed to be size rejecting for various ampere rating ranges. Therefore, ECF fuses greater than the specific ampere rating range are rejected

Blade-Fuse Part No.	Fuse Rating	Maximum Ampere Rating Physical Restriction
ECF-1/2	1/2A	2A
ECF-1	1A	
ECF-11/2	11/2A	
ECF-2	2A	
ECF-3	3A	4A
ECF-4	4A	
ECF-5	5A	6A

240.60(D) Renewable Fuses

The 2005 NEC® has new requirements that prohibit the use of Class H renewable fuses for new installations. The reasoning given in the original proposal submitted for this restriction was that renewable fuses were posing significant safety issues. The code making panel statement did not support the claims of the safety issues, however, they chose to support the proposal because of the minimal 10,000 amp interrupting rating. Renewable fuses that are applied within their ratings and where there is no evidence of tampering are permitted for replacement in existing installations.

This new requirement supports the use of devices with higher interrupting ratings. New equipment should be installed using Fusetron® (RK5) fuses which have a 200,000A IR, or preferably Low-Peak® (RK1, J, CC or L) fuses which have a 200,000A IR for LP-CC fuses and 300,000A IR for the others. It is also important if Class R fuses are used, then install switches with rejection fuse clips, so that Class H fuses cannot be used for later replacement. Class J, L, T, CC, and G fuses, as well as, the CUBEFuse™ mounting are all physical size rejecting so only that respective Class of fuse can be installed. This ensures the installation maintains its high interrupting rating.

In addition to the highest interrupting ratings of all overcurrent protective devices, modern current-limiting fuses provide:

- The best equipment protection
- The easiest overcurrent protective devices to selectively coordinate
- Reliable overcurrent protection over the life of the system
- No maintenance necessary
- The best reduction of the arc flash hazard when the arcing current is within the current limiting range of the fuse
- Physical size rejecting feature
- Class R fuses can be installed in Class H clips.

New Requirement

2005 NEC®
240.60(D) Renewable Fuses. Class H cartridge fuses of the renewable type shall only be permitted to be used for replacement in existing installations where there is no evidence of overfusing or tampering.

Example of renewable fuses

Low-Peak current-limiting fuses

410.73(G) Disconnecting Means for Electric-Discharge Lighting Systems

The 2005 NEC® has a new article requiring individual disconnecting means for ballasted electric discharge lighting that have double ended lamps, or those that are fed by multiwire branch circuits (with some exceptions). Industry data has shown that a leading cause of fatalities for electricians is electrocution while working on 277V lighting systems. Electricians are often pressured to change out ballasts while the circuits are energized to avoid removing illumination from an area. When the electrician gets to the wire nut with three white wires (neutral), the thought is that theses are grounded conductors, and therefore are not hazardous. The electrician opens the wire nut and gets between two of the white wires, which can result in shock or electrocution. These white wires carry the unbalanced load current from all phases of the white wires.

This new requirement will allow electricians to de-energize a ballasted luminaire without removing illumination to an entire area. Then they can safely change out the ballast without being exposed to a shock hazard. This change has been given an effective date of January 1st, 2008 to allow manufacturers time to develop products for this application.

430.52(C)(6)
Self-Protected Combination Controller

Individual Pole-Interrupting Capability

Self-protected combination controllers are intended to provide motor overload, and motor branch circuit short-circuit and ground fault protection. They are essentially the same as circuit breakers when it comes to short-circuit protection. And like circuit breakers, they have limitations on how much short-circuit current a single pole can interrupt (individual pole interrupting capability). Self-protected combination controllers are listed to UL 508 Industrial Control Equipment. UL508 Table 82A.3 specifies the short circuit test values on one pole as 8,660 amps for 0 to 200 hp devices rated up to 600 volts and 4320A for 0 to 10hp devices rated 200 to 250V. Self-protected combination controllers may not be able to safely interrupt single-pole faults above these values. **These devices must not be used in an application where a single pole is subjected to more fault current than specified in UL 508 (8,660A for 0 to 200 hp devices rated up to 600 volts and 4320A for 0 to 10hp devices rated 200 to 250V). This may easily occur on corner grounded delta systems, impedance grounded systems, and ungrounded systems.**

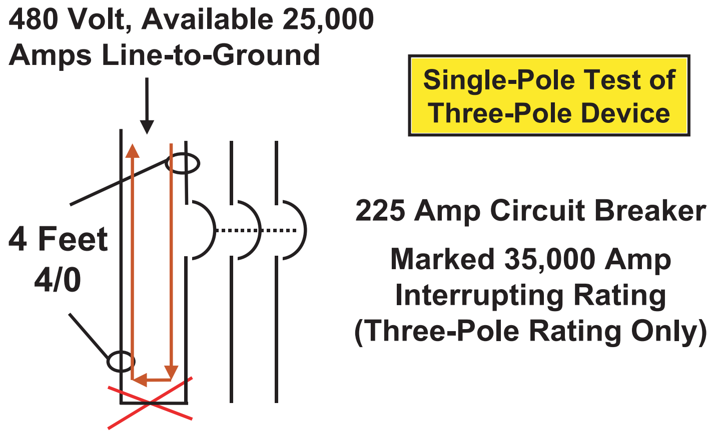
For this reason a FPN was added to the 2005 NEC® that matches the FPN added to 240.85 for the 2002 NEC® for circuit breakers. While the FPN is not a requirement it does alert users that proper application of these devices takes the individual pole interrupting capability into consideration.

New Fine Print Note

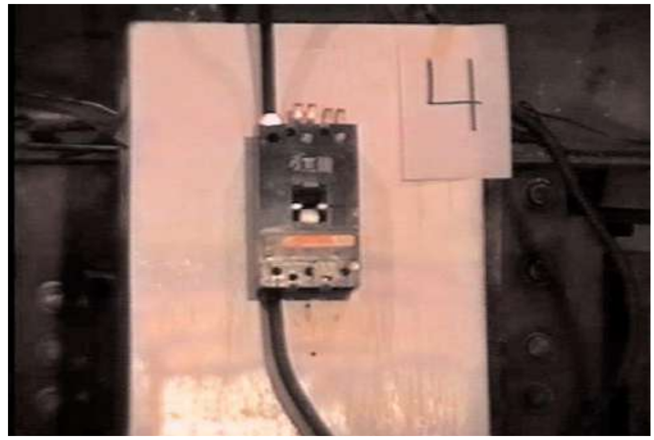
2005 NEC®
430.52(C)(6) FPN: Proper application of self-protected combination controllers on 3-phase systems, other than solidly grounded wye, particularly on corner grounded delta systems, considers the self-protected combination controllers' individual pole-interrupting capability.

Individual-Pole Interrupting Ratings

This is a single-pole interrupting test on a circuit breaker to illustrate the concept.



This device is tested for three-pole interruption with available fault of 35kA and is test for individual single-pole interruption of only 8,660 amps per UL 489



Test set up prior to closure of test station

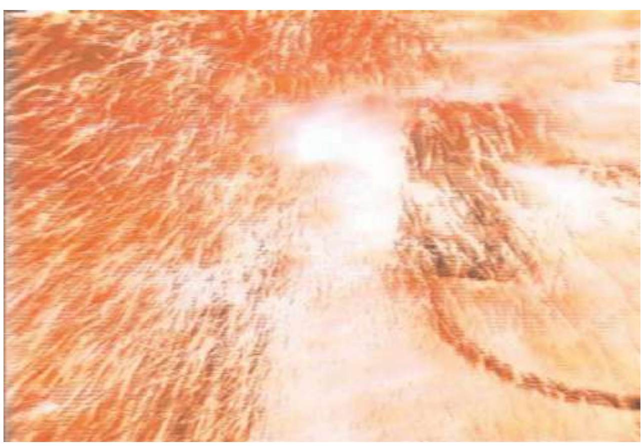


Photo of 3-pole device during test of individual single-pole interruption of a fault current beyond the tested values specified by the UL standard

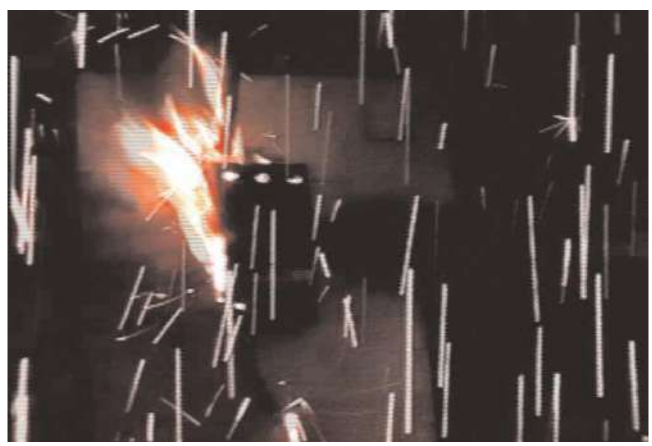


Photo (later in sequence) of 3-pole device during test of individual single-pole interruption of a fault current beyond the tested values specified by the UL standard

430.83(E) Voltage Rating for Motor Controllers

Slash Voltage Rating

The 2005 NEC® section covering voltage ratings for motor controllers was changed to address the proper application of slash-rated devices. A slash-rated motor controller is one with two voltage ratings separated by a slash, such as 480Y/277 volt. The change was the addition of the words "solidly grounded". This was needed to emphasize that slash-rated devices are not appropriate for use on corner grounded delta, resistance-grounded and ungrounded systems.

This typically pertains to the self-protected combination controllers mentioned in the previous section. Most of them are "dual listed." Dual listed controllers will have one listing as a manual motor controller that has a straight 480 volt rating. When used as a manual motor controller they can be used any 480 volt system, but they must be protected by a fuse or circuit-breaker. Dual listed devices also have a second listing as a self-protected motor controller. The self-protected starter listing is nearly exclusively rated 480Y/277. These slash-rated devices cannot be used on corner-grounded delta, resistance grounded, or ungrounded systems.

Where it is possible for full phase-to-phase voltage to appear across only one pole, a slash-rated device is not acceptable. These self-protected starters are typically listed with a straight 480 volt rating when utilized as a manual motor controller. As such, they can be used on other than solidly grounded systems, but only for their on/off function and overload protection.

When slash-rated devices such as self-protected motor controllers are installed in equipment, it limits the application of the equipment to solidly grounded wye systems. The equipment nameplate must also be marked with the slash-rating (e.g. 480Y/277) to clearly indicate that it is limited by the type of grounding system. This limits the entire equipment or panel to solidly grounded systems only.

The advantage of fuses is that they are tested with full voltage across the fuse, and therefore are not limited by the type of grounding systems. Equipment that has slash-rated devices for short-circuit protection can often be retrofitted with fuses (such as LP-CC fuses with the OPM-NG holder) to eliminate the limitations.

2005 NEC®
VII. Motor Controllers
430.83 Ratings.
(E) Voltage Rating. A controller with a straight voltage rating, for example, 240 volts or 480 volts, shall be permitted to be applied in a circuit in which the nominal voltage between any two conductors does not exceed the controller's voltage rating. A controller with a slash rating, for example, 120/240 volts or 480Y/277 volts, shall only be applied in a solidly grounded circuit in which the nominal voltage to ground from any conductor does not exceed the lower of the two values of the controller's voltage rating and the nominal voltage between any two conductors does not exceed the higher value of the controller's voltage rating.

Ensuring Compliance

Solidly Grounded WYE System

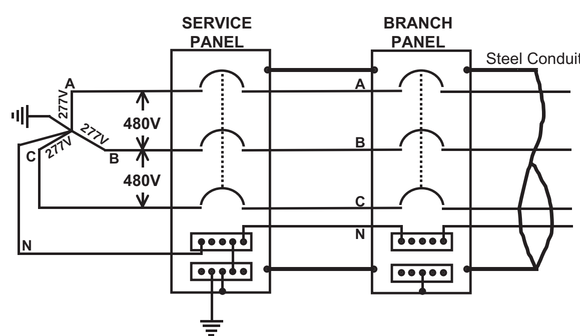


Figure 1 – Solidly Grounded WYE System

Solidly Grounded WYE System

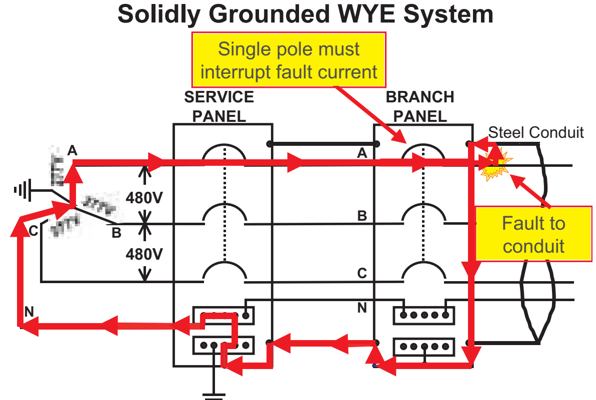


Figure 2 – Single-Pole Fault to Ground in Solidly Grounded WYE System

In solidly grounded wye systems, the first low impedance fault to ground is generally sufficient to open the overcurrent device on the faulted leg. In Figure 2, this fault current causes the branch circuit overcurrent device to clear the 277V fault. This system requires compliance with single-pole interrupting capability for 277V faults on one pole. If the overcurrent devices have a single-pole interrupting capability adequate for the available short-circuit current, then the system meets NEC® 110.9. When other than solidly grounded wye systems are encountered, it is absolutely essential that the proper application of single-pole interrupting capabilities be assured. This is due to the fact that full phase-to-phase voltage can appear across just one pole. Phase-to-phase voltage across one pole is much more difficult for an overcurrent device to clear than the line-to-neutral voltage associated with the solidly grounded wye systems.

The system of Figure 3 has a delta-connected secondary and is solidly grounded on the B-phase. If the B-phase should short to ground, no fault current will flow because it is already solidly grounded. If either Phase A or C is shorted to ground, only one pole of the branch-circuit overcurrent device will see the 480V fault as shown in Figure 4. This system requires compliance with single-pole interrupting capabilities for 480V faults on one pole because the device would be required to interrupt 480V with only one pole.

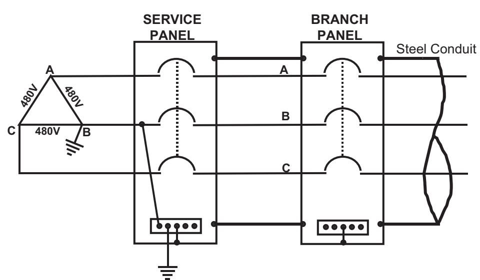


Figure 3 – Corner-Grounded Delta System (Solidly Grounded)

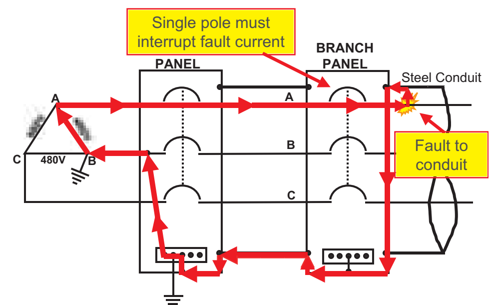
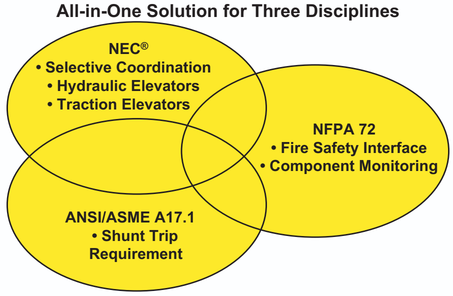


Figure 4 – Fault to Ground on a Corner Grounded Delta System

Elevator Circuit Requirements

The NEC® requirements discussed on the next two pages are not new nor have they changed with the 2005 NEC®. However, elevator circuits are an important application for life safety. In addition, usually there are three disciplines involved in the design, installation, and inspection of elevator systems; this can result in complications and even improper installations.



When sprinklers are installed in elevator hoistways, machine rooms, or machinery spaces, ANSI/ASME A17.1 requires that the power be removed to the affected elevator upon or prior to the activation of these sprinklers. This is an elevator code requirement that affects the electrical installation. The electrical installation allows this requirement to be implemented at the disconnecting means for the elevator in NEC® **620.51(B)**. This requirement is most commonly accomplished through the use of a shunt trip disconnect and its own control power. To make this situation even more complicated, interface with the fire alarm system along with the monitoring of components required by NFPA 72 must be accomplished in order to activate the shunt trip action when appropriate and as well as making sure that the system is functional during normal operation. This requires the use of interposing relays that must be supplied in an additional enclosure. Other requirements that have to be met include selective coordination for multiple elevators (620.62) and hydraulic and some traction elevators with battery lowering [620.91(C)].

Safety considerations discussed on these two pages are selective coordination requirements for elevator circuits and hydraulic and some traction elevators with battery backup/auto recall.

620.62 Selective Coordination Elevator Circuits

NEC® Requirement under Article 620 which includes Elevators

For these elevator circuits, a design engineer must specify, the contractor must install, and the inspector should enforce main, feeder, sub-feeder, and branch circuit protective devices that are selectively coordinated for all possible values of overloads and short-circuits for the system.

One of the reasons that coordination is so important is because firefighters commonly use the elevator to get closer to a fire during fire-fighting operations and elevators are a means of egress in emergencies. When more than one driving machine is fed from a single feeder, selective coordination is required between the overcurrent protective device (OCPD) in each disconnecting means and any other supply side overcurrent protective devices. This requires all the overcurrent protective devices from the elevator disconnect to the main to be selectively coordinated with one another. For a brief discussion as to what selective coordination means go to page 8 in this publication.

For example, in Figures 1 and 2, if a fault were to occur on B1, B2, B3 or B4 (or F4) that would cause overcurrent protective devices F2 or M1 to open in Figure 1 and F1, F2, F3, or M1 to open in Figure 2. If M1 opens, the entire system is blacked out; most are all of the elevators in the building would lose power. If a fault were to occur on F2 that would cause M1 to open, all of the elevators in the building would lose power. These conditions described are a lack of selective coordination and not in compliance with 620.62. Note, in attempt to get around the 620.62 requirement for Figure 1, some designers incorrectly believe the scheme in Figure 2 does not require selective coordination. For the layout in Figure 2, 620.62 requires F1, F2, F3, and F4 to be selectively coordinated with M1.

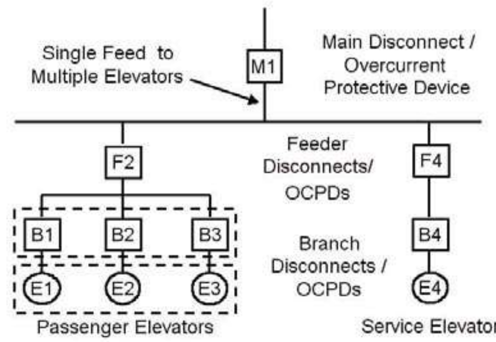


Figure 1

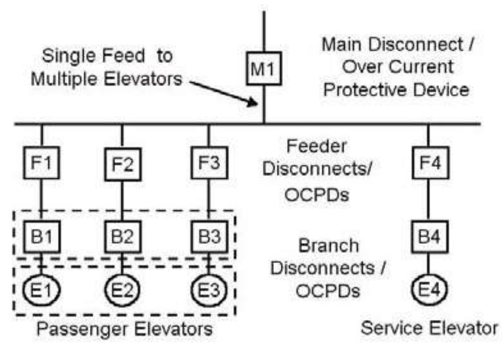


Figure 2

620.91 Emergency & Standby Power Systems (C) Disconnecting Means (Elevators)

The elevator disconnecting means referenced in NEC® 620.51, for maintenance purposes, must be capable of disconnecting all sources of power including those on the load side of the elevator. NEC® 620.91(C) covers elevators, which have an emergency power supply on the load side of the elevator disconnecting means required per NEC® 620.51. NEC® 620.91(C) requires removal of all sources of power including those on the load side of the elevator disconnecting means. Hydraulic and traction elevators have the capability of using a battery pack to lower the elevator in a loss of power situation. The battery attachment is utilized as an extra level of safety to keep from stranding people in the elevator for long periods of time. For instance with hydraulic elevators under normal operation, the main line power from the disconnecting means controls the raising of the elevator through a pump motor and the lowering of the elevator through a solenoid and a drain valve. To send the cab upward, the pump motor pumps hydraulic fluid into the piston that forces the elevator upward. To return the cab back down, a drain valve at the bottom of the piston is opened by a solenoid valve and as the fluid drains back into the reservoir, the elevator lowers. If the main line power is lost, this battery pack attachment can supply enough power to actuate the solenoid.

For the battery backup feature to operate properly, auxiliary contacts need to be in the controller and the disconnecting means. In addition, the disconnect/overcurrent protection in conjunction with the auxiliary contact must function properly for various operating scenarios. See Figure 3 has an illustrative diagram. A complete explanation of the various operating scenarios can not be presented in this publication.

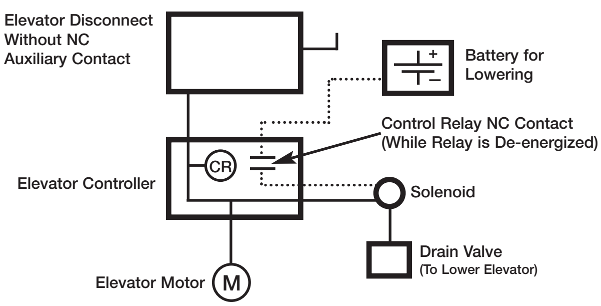


Figure 3 Normal Operation per NEC® 620.91(C) – this complies

It is important to recognize that the type disconnect used for the elevator shunt-trip device has a direct bearing on whether the battery backup functions as intended and whether the systems complies with 620.91(C). If not, there may be a safety hazard. There typically are three options considered for shunt-trip elevator disconnects with integral auxiliary contacts. Only one of these three work properly for elevators with battery backup for all scenerios:

1. Fusible shunt-trip switch with auxiliary contacts – (Cooper Bussmann Power Module™)
2. Fusible shunt-trip molded case switch (with an instanta neous trip override) with auxiliary contacts
3. Shunt-trip molded case circuit breaker with auxiliary contacts

Only the first option, the fusible shunt-trip switch with auxiliary contacts, provides the proper functioning if there is an overcurrent that opens one or more fuses in the disconnect. In this case the fuse(s) open resulting in a loss of power for one or more phases, but the auxiliary contacts in the disconnect do not change state. So the battery backup function can work as intended.

For options 2 and 3, a branch circuit overcurrent that causes them to open may open the auxiliary contact and not allow battery backup to function as intended, which may be a safety issue. The molded case switch, option 2, has an instantaneous trip override that operates at a certain overcurrent level and beyond. When such an overcurrent occurs, the switch opens and the auxiliary contact opens. So for an overcurrent condition with option 2, the fusible molded case switch, may open and battery backup does not operate as intended. Whenever the molded case breaker, option 3, clears an overcurrent, the circuit opens and the auxiliary contact opens. Option 1 is the only option that properly operates and doesn't strand passengers.

The POWER MODULE™ contains a shunt trip fusible switch together with the components necessary to comply with the fire alarm system requirements and shunt trip control power all in one UL Listed package. For engineering consultants this means a simplified specification. For contractors this means a simplified installation because all that has to be done is connecting the appropriate wires. For inspectors this becomes simplified because everything is in one place with the same wiring every time. The fusible portion of the switch utilizes LOW-PEAK® LPJ-(amp)SP fuses that protect the elevator branch circuit from the damaging effects of short-circuit currents as well as helping to provide an easy method of selective coordination when supplied with upstream LOW-PEAK fuses with at least a 2:1 amp rating ratio. Note the POWER MODULE™ only accepts Class J fuses which have a physical size rejection feature (only Class J fuses accepted) and Class J fuses have 200,000A or 300,000A interrupting rating.

COOPER Bussmann®

Productivity Through Protection™

Update on 2008 Code Changes

Table Of Contents

Selective Coordination Requirements

Background

Selective coordination of all upstream overcurrent protective devices in the supplying circuit paths is required by the NEC® for a limited number of specific vital loads. These requirements increase system reliability and load availability for life safety. Requirements for selective coordination of all overcurrent protective devices supplying elevator circuits first appeared in the 1993 NEC®. The 2005 NEC® added selective coordination requirements for all overcurrent protective devices in the circuit paths supplying emergency system loads and legally required standby loads, plus in healthcare facilities, the essential electrical system loads. The 2008 NEC® retained the previous selective coordination requirements, plus added the selective coordination requirement for all overcurrent protective devices in circuit paths to loads of critical operations power systems (COPS - new Article 708). In addition, two exceptions were added to 700.27 and 701.18; however, these exceptions did not alter the requirements but rather provided clarification for two circumstances.

The 2008 Requirements

Article 100 Definitions
Coordination (Selective).
Localization of an overcurrent condition to restrict outages to the circuit or equipment affected, accomplished by the choice of overcurrent protective devices and their ratings or settings.

Article 517 Healthcare Facilities
517.26 Application of Other Articles.
The essential electrical system shall meet the requirements of Article 700, except as amended by Article 517. (Note: Article 517 has no amendment to the selective coordination requirement, therefore selective coordination is required.)

Article 620 Elevators
620.62 Selective Coordination
Where more than one driving machine disconnecting means is supplied by a single feeder, the overcurrent devices in each disconnecting means shall be selectively coordinated with any other supply side overcurrent protective devices.

700.9(B)(5)(b), Exception.
Overcurrent protection shall be permitted at the source or for the equipment, provided the overcurrent protection is selectively coordinated with the down stream overcurrent protection.

Article 700 Emergency Systems
700.27 Coordination.
Emergency system(s) overcurrent devices shall be selectively coordinated with all supply side overcurrent protective devices.
Exception: Selective coordination shall not be required in (1) or (2):
(1) Between transformer primary and secondary overcurrent protective devices, where only one overcurrent protective device or set of overcurrent protective devices exist(s) on the transformer secondary,
(2) Between overcurrent protective devices of the same size (ampere rating) in series.

Article 701 Legally Required Standby Systems
701.18. Coordination.
Legally required standby system(s) overcurrent devices shall be selectively coordinated with all supply side overcurrent protective devices.
Exception: Selective coordination shall not be required in (1) or (2):
(1) Between transformer primary and secondary overcurrent protective devices, where only one overcurrent protective device or set of overcurrent protective devices exist(s) on the transformer secondary,
(2) Between overcurrent protective devices of the same size (ampere rating) in series.

Article 708 Critical Operations Power Systems
708.54 Selective Coordination
Critical operations power system(s) overcurrent devices shall be selectively coordinated with all supply side overcurrent protective devices.

Why Selective Coordination is Important

The progressive inclusion of additional selective coordination requirements in the NEC® is the result of increased focus on life safety in the NEC®. Other recent notable life safety additions in the 2008 NEC® are the expansion of requirements for AFCIs and the addition of tamper-proof receptacles. Selective coordination is a requirement intended to keep certain vital loads powered as long as possible, especially in times of emergency or critical need. Our building systems have evolved to the point where certain electrical loads are absolutely vital for sustaining life, for the evacuation of facilities or for the safe continuous operation of facilities. Recent catastrophic events such as 9/11 and hurricane Katrina have highlighted the need to require a higher level of system reliability, thus ensuring higher availability for certain designated electrical loads. As part of a building is damaged or failing, the objective is to maintain power to each vital load as long as possible; whether the normal source is still powering the loads or the alternative source has been called upon to power these vital loads.

Vital Loads

Emergency systems are considered in places of assembly where artificial illumination is required, for areas where panic control is needed such as hotels, theaters, sports arenas, health care facilities, and similar institutions, and where interruption of power to a vital load could cause severe human safety hazards. Emergency loads may include emergency and egress lighting, ventilation and pressurization systems, fire detection and alarm systems, elevators, fire pumps, public safety communications, or industrial process loads where interruption could cause severe human safety hazards. Article 700 provides the requirements.

Legally required standby systems are intended to supply power to selected loads in the event of failure of the normal source. Legally required standby systems typically serve loads in heating and refrigeration, communication systems, ventilation and smoke removal systems, sewage disposal, lighting systems, and industrial processes where interruption could cause severe human safety hazards. Article 701 provides the requirements.

Where hazardous materials are manufactured, processed, dispensed, or stored, then the loads that may be classified to be supplied by emergency or legally required standby systems include ventilation, treatment systems, temperature control, alarm, detection, or other electrically operated systems.

Essential electrical systems in healthcare facilities are portions of the electrical system designed to ensure continuity of lighting and power to designated areas/functions during normal source power disruptions or disruptions within the internal wiring system. Essential electrical systems can include the critical branch, life safety branch, and equipment systems which are essential for life safety and orderly cessation of procedures during normal power disruptions. Article 517 provides the requirements and 517.26 refers to Article 700 requirements.

Critical Operations Power Systems (COPS) are systems intended to provide continuity of power to vital operations loads. COPS are intended to be installed in facilities where continuity of operations is important for national security, the economy, or public safety. These systems will be classified COPS by government jurisdiction or facility management. The type of loads may be any and all types considered vital to a facility or organization including data centers and communications centers. New Article 708 provides the requirements.

The objective of Article 700, 701, and 708 requirements is to ensure availability and reliability of electrical power to these vital loads with the goal of safety of human life during emergencies, man made or natural catastrophic events, or loss of the normal power. These articles have numerous requirements that are intended to increase reliability, reduce the probability of faults, and minimize the effects of negative events to the smallest portion of system as possible: all to keep the vital loads up and running as long as possible. Selective coordination of overcurrent devices is another logical requirement that helps ensure a higher system reliability and availability of electrical power to vital loads. The following are examples of a few other Article 700 requirements with similar intent:

- 700.4 maintenance and testing requirements
- 700.9(B) emergency circuits separated from normal supply circuits
- 700.9(C) wiring specifically located to minimize system hazards
- 700.16 failure of one component must not result in a condition where a means of egress will be in total darkness

What is Selective Coordination?

Selective coordination can be defined as isolating an overloaded or faulted circuit from the remainder of the electrical system by having only the nearest upstream overcurrent protective device open. Overcurrent protective devices are deemed selectively coordinated only when the nearest upstream overcurrent protective device opens for any possible overcurrents (overload or fault current) that could occur in a specific application. For example, when a fault occurs on a branch circuit, only the branch-circuit fuse or circuit breaker should open. See Figure 1. Similarly, when a fault occurs on a feeder, only the nearest upstream feeder fuse or circuit breaker should open.

Selective Coordination
Includes the Entire Circuit Path

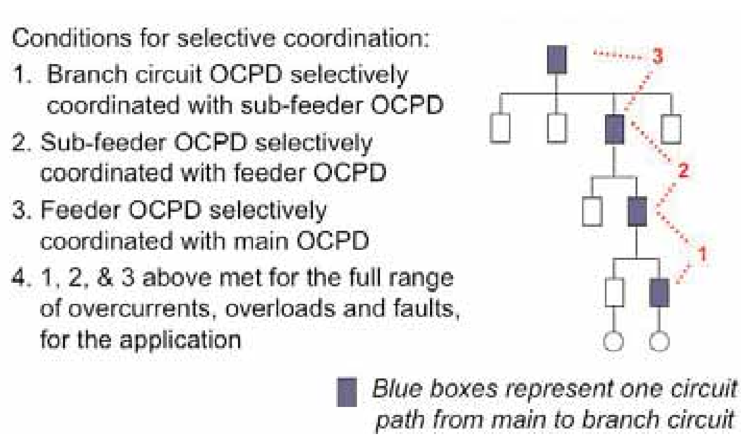


Figure 1

The one-line diagrams in Figure 2 and Figure 3 demonstrate the concept of selective coordination. Figure 2 illustrates the circuit path for emergency loads powered by the normal power source and Figure 3 illustrates the circuit path for emergency loads powered by the alternate source. If over-current protective devices in circuit paths supplying emergency loads are not selectively coordinated, a fault at X1 on the branch circuit may unnecessarily open the sub-feeder; or even worse the feeder or possibly even the main. In this case, emergency loads are unnecessarily blacked out. With selective coordination as a requirement for emergency, legally required standby, and essential electrical loads, when a fault occurs at X1 only the nearest upstream fuse or circuit breaker supplying just that circuit would open. Other emergency loads would remain powered. The same analysis can be made for faults occurring at the feeder level.

Normal Path and Alternate Path

For these vital loads, selective coordination is required for both the normal power circuit path and the alternate power circuit path. The requirements state selective coordination is required, "with all supply side overcurrent protective devices". Selective coordination is about the continuance of power to vital loads. These vital loads in the emergency systems, legally required standby systems, critical operations power systems, and essential electrical systems can be powered through the normal source or through the alternate source. The overcurrent protective devices must be selectively coordinated from each load branch circuit up through both the normal source main and alternative source. Code Panels 12, 13, and 20 carefully chose their words with all supply side overcurrent devices for this requirement, because they wanted to assure that these vital loads are not disrupted, whether fed from the normal source or the alternate source.

There are several reasons for this. If the overcurrent protective devices are not selectively coordinated in the normal path to the vital loads, a fault can cause the OCPDs to cascade thereby unnecessarily opening the feeder on the loadside of the transfer switch as well as the feeder and service on the lineside of transfer switch. This action reduces the reliability of the system since there is some probability that the generator may not start or the transfer switch may not transfer. In addition, when the generator starts and the loads transferred to the alternate source, some vital loads will be unnecessary blacked out due to the feeder OCPD's lack of selective coordination (it is still open unnecessarily). In assessing whether the overcurrent protective devices are selectively coordinated in the circuit path for these vital loads, it is important that the available short-circuit current from the normal source be considered since it may cause fault currents much higher than from the alternate source.

Full Range of Overcurrents

To comply, the overcurrent protective devices must selectively coordinate for the full range of overcurrents possible for the application. It is not selective coordination if the fuses or circuit breakers are coordinated only for overloads and low level fault currents. The fuses or circuit breakers must also be selectively coordinated for the maximum short-circuit current available at each point of application. In a Panel Statement during the 2008 ROP cycle, Code Panel 13 responded to a proposal to alter the selective coordination requirement: "…the instantaneous portion of the time current curve is no less important than the long time portion." Higher level faults may not occur as frequently as lower level faults, but they can and do occur. Higher level faults will be more likely during fires, attacks on buildings, or building failures or more likely as the system ages, or if proper maintenance is not performed regularly. Also, all too often, the circuits for these vital loads may be worked on while energized and a worker-caused fault can be of a significant fault level.

Selective coordination has a very clear and unambiguous definition. Either overcurrent protective devices in a circuit path are selectively coordinated for the full range of over currents for the application or they are not. The words "optimized selective coordination", "selectively coordinated for times greater than 0.1 seconds", or other similar wording are merely attempts to not meet the selective coordination requirements. And terms like "selective coordination where practicable" is unenforceable. Code Panels 12, 13, and 20 have discussed and declined any wording that lessens the requirement from the full range of overcurrents or lessens the enforceability.

Faster Restoration & Increased Safety

Besides minimizing an outage to only the part of the circuit path that needs to be removed due to an overcurrent condition, selective coordination also ensures faster restoration of power when only the closest upstream overcurrent protective device opens on an overcurrent. When the electrician arrives to investigate the cause, correct the cause, ensure the integrity of the circuit components for re-energization, and restore power, the electrician does not have to spend time locating upstream overcurrent protective devices that unnecessarily opened. This also increases safety by avoiding unneccessary reclosing or replacing OCPDs.

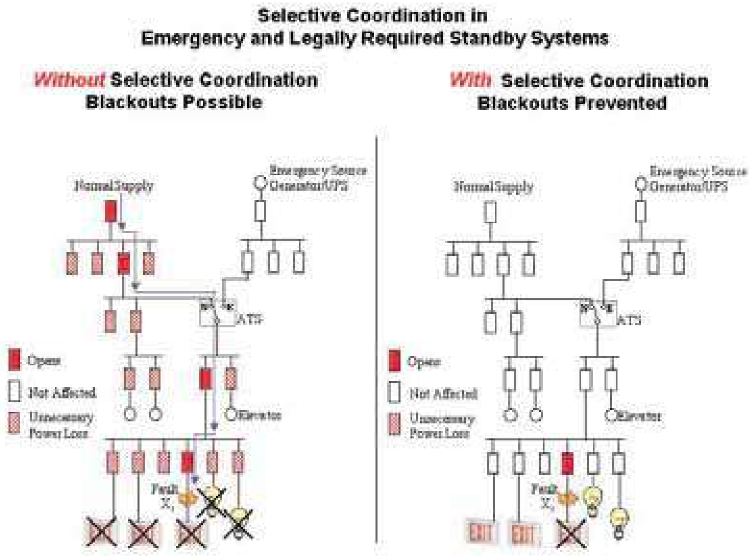


Figure 2 - Emergency loads powered by normal source

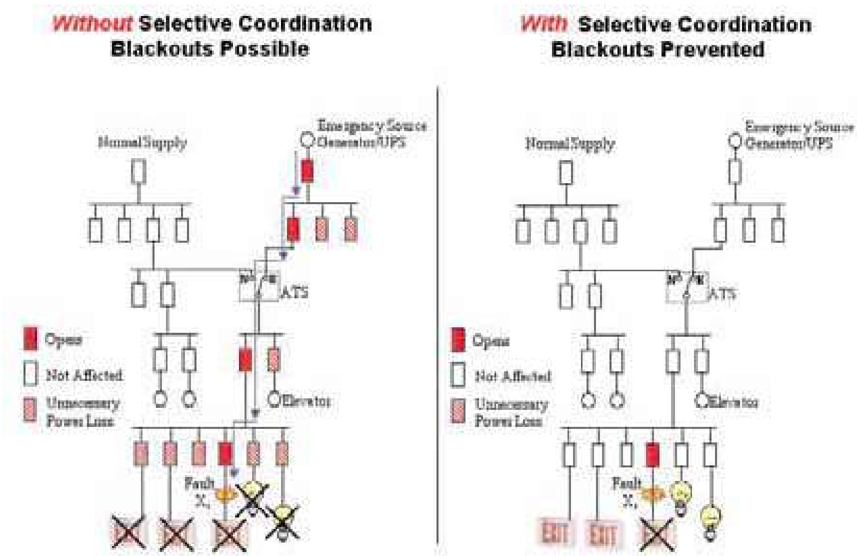


Figure 3 - Emergency loads powered by alternative source

Ensuring Compliance

Achieving the proper overcurrent protective device selective coordination requires proper engineering, specification and installation of the required overcurrent protective devices. It is possible for both fusible or circuit breaker systems to be selectively coordinated with proper analysis and selection. See the section Achieving Selective Coordination.

Authority Having Jurisdiction (AHJ): the AHJ does not have to be an expert at overcurrent device coordination to enforce the selective coordination requirements. It is a simple matter of requiring a professional engineer to provide his or her seal on documentation that states selective coordination is achieved. The documentation should include a selective coordination analysis and the specified overcurrent devices with pertinent information on type, ampere ratings, and options/settings, if appropriate. During site inspection, the AHJ may choose to spot check the installation to see if the installation is as specified. It is advisable for the jurisdiction to proactively let the electrical community know that the requirements are being enforced. If the contractor installs a non-selectively coordinated system that gets red tagged, the cost and time to correct the system are often substantial.

Engineers: Selective coordination is best resolved in the design phase. Depending on the load needs and types of overcurrent protective devices, engineers have flexibility. It is the engineer's responsibility to provide documentation that verifies the overcurrent devices are selectively coordinated for the full range of overcurrents that can occur in the system.

If fuses are used, a circuit schedule with Cooper Bussmann fuse types and ampere ratings adhering to the Cooper Bussmann fuse selectivity ratios is the easiest verification analysis method. The selectivity ratios are valid for all overcurrent conditions up to the interrupting rating of the fuses.

If circuit breakers are used, it is necessary to do a short-circuit current study, plot the time-current characteristic curves, and interpret the data properly. In some cases, circuit breaker manufacturers publish tables showing at what values of short-circuit current their circuit breakers coordinate. A schedule is needed that shows the circuit breaker types, options, settings, and available short-circuit currents. The schedule should reference the corresponding time-current curve with interpretation analysis or the manufacturer's coordination tables showing how the circuit breakers are selectively coordinated for the full range of overcurrents. If alternatives are submitted, the same documentation as above should also be submitted so that the engineer can assess that selective coordination is achieved.

Installer: the contractor should install per the engineer's specifications or approved submittals. If the system is circuit breakers, the installer must ensure the circuit breaker settings (short-time delay and instantaneous trip) are set per the engineer's coordination analysis. Circuit breakers are shipped from the manufacturers with the short-time delay and instantaneous trip settings on low or the minimum; these settings may require adjustment.

Achieving Selective Coordination

Following is a brief overview of achieving selective coordination with fuses or circuit breakers. At the time of this publication, materials are being developed, so please check periodically, if interested in a more in-depth discussion. Also, publication SPD – Selecting Protective Devices, Based on the 2005 NEC has a more in-depth discussion. The 2008 NEC version of the SPD publication will be updated with more selective coordination information and is planned to be available in early 2008.

Fuse Systems

Cooper Bussmann makes it easy to design and install fusible systems that are selectively coordinated. For modern current-limiting, low voltage fuses, selectivity ratios are published. Figure 4 illustrates a Fuse Selectivity Ratio Table for the fuses in the example. It is not necessary to plot time current curves or do a short-circuit current analysis; all that is necessary is to make sure the fuse types and ampere rating ratios for the mains, feeders and branch circuits meet or exceed the selectivity ratios. If the ratios are not satisfied, then the designer should investigate another fuse type or design change. These selectivity ratios are for all levels of overcurrent up to the interrupting ratings of the respective fuses. The ratios are valid even for fuse opening times less than 0.01 seconds. This means with current-limiting fuses, it is not necessary to do any analysis for less than 0.01 seconds when the fuse types and ampere rating ratios adhere to the selectivity ratios. The installer just needs to install the proper fuse type and ampere rating. There are no settings to adjust. The following example illustrates all that is necessary to achieve selective coordination with a fusible system.

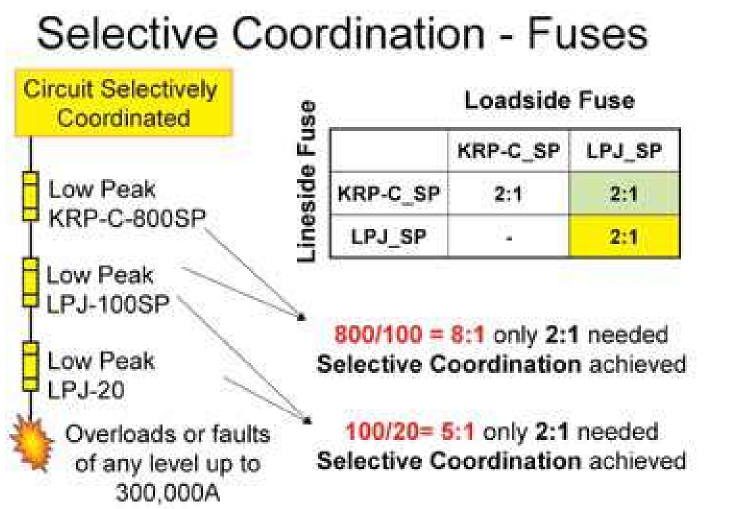
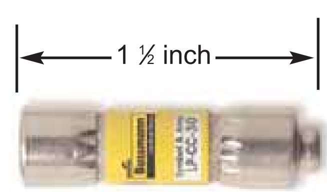


Figure 4 - Using the Fuse Selectivity Ampere Rating Ratios

In order to provide a selectively coordinated fusible system, fusible branch circuit lighting panels may be needed.To ful-fill this need, Cooper Bussmann has the Coordination Module, a fusible branch circuit lighting panel. The coordination module branch circuits incorporate Class CC fuses (LP-CC) for branch circuit protection. Fuseholders with easyID Neon Indicator provide open fuse indication. Class CC fuses are available from 1/10 to 30A.



LP-CC Fuse

Cooper Bussmann® Coordination Module

Circuit Breaker Systems

Systems can be designed with circuit breakers where selective coordination can be achieved. It is important that the curves and circuit breaker functionality are interpreted properly by a qualified person. Typically the steps necessary are:

1. Short-circuit current calculation study: Determine the available short-circuit current (both normal source and alternate source) at every point of application in order to select the proper interrupting rated circuit breakers and to interpret the curves as to whether a circuit breaker scheme is selectively coordinated for the specific application.
2. Time current characteristic analysis: Plot the curves for the circuit breakers of each circuit path, note the available short-circuit currents, and determine if the circuit breakers for that circuit path are selectively coordinated. If not, then,
3. Trial and error method: try various setting adjustments, CB types, options, or design change.

Figure 5 illustrates a circuit breaker system where the 20A branch circuit breaker is selectively coordinated with the 100A feeder circuit breaker as long as the available short circuit current at the branch panel does not exceed 900A. Also, this figure illustrates the 100A feeder circuit breaker is selectively coordinated with the 800A main circuit breaker, which has a short-time delay. Figure 6 illustrates a system where the 20A, 100A and 800A circuit breakers are selectively coordinated for all levels of available short-circuit current up to their respective interrupting ratings. This is achieved by using feeder and main circuit breakers with short-time delays (without any instantaneous override feature).

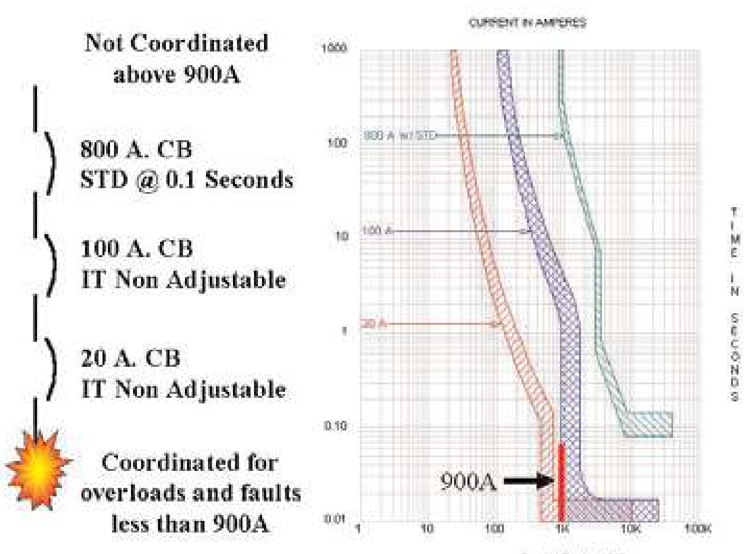


Figure 5

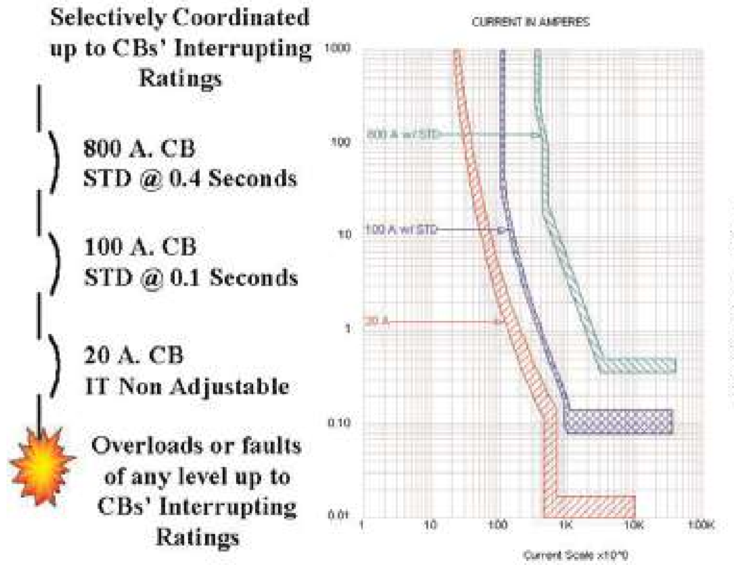


Figure 6

Circuit Breaker Selective Coordination Alternatives

1. MCCBs, ICCB,s and LVPCBs with instantaneous trip settings
2. MCCBs with fixed high magnetic trip or larger frame size may allow higher instantaneous trip
3. CBs coordinated to manufacturer's tested coordination tables
   - CB manufacturers have coordination testing on many MCCBs
   - These tables can enable circuit breakers to coordinate for fault currents higher than shown on the time current curves
4. CBs with short time delay having instantaneous trip override
   - MCCBs and ICCBs with short-time delay settings, typically have an instantaneous trip override that opens the CB instantaneously for higher fault currents (10X to12X amp rating)
   - ICCBs and some LVPCBs may have higher instantaneous override settings than MCCBs
5. ICCBs and LVPCBs with short time delay (with no instantaneous override): allow sufficient separation between time current bands

Notes:

- The instantaneous trip of upstream circuit breakers must be greater than the available short-circuit current for alternatives 1, 2, and 4
- Interpret the time current curves properly
- Some options may require larger frame size or different type CBs
- Maintenance and testing should be performed periodi cally or after fault interruption to retain proper clearing times and the coordination scheme

Selective Coordination of Elevator Circuits

NEC® Requirement under Article 620 which includes Elevators

> For these elevator circuits, a design engineer must specify, the contractor must install, and the inspector should enforce main, feeder, sub-feeder, and branch circuit protective devices that are selectively coordinated for all possible values of overloads and short-circuits for the system.

One of the reasons that selective coordination is so important is because firefighters commonly use the elevator to get closer to a fire during fire-fighting operations and elevators are a means of egress in emergencies. When more than one driving machine is fed from a single feeder, selective coordination is required between the overcurrent protective device (OCPD) in each disconnecting means and any other supply side overcurrent protective devices. This requires all the overcurrent protective devices from the elevator disconnect to the main to be selectively coordinated with one another.

For example, in Figures 1 and 2, if a fault were to occur on B1, B2, B3 or B4 (or F4) that would cause overcurrent protective devices F2 or M1 to open in Figure 1 and F1, F2, F3, or M1 to open in Figure 2. If M1 opens, the entire system is blacked out; most are all of the elevators in the building would lose power. If a fault were to occur on F2 that would cause M1 to open, all of the elevators in the building would lose power. These conditions described are a lack of selective coordination and not in compliance with 620.62. Note, in attempt to get around the 620.62 requirement for Figure 1, some designers incorrectly believe the scheme in Figure 2 does not require selective coordination. For the layout in Figure 2, 620.62 requires F1, F2, F3, and F4 to be selectively coordinated with M1.

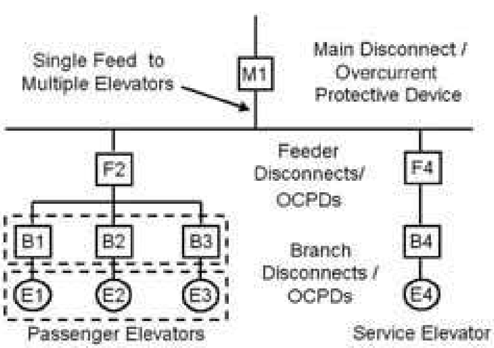


Figure 1

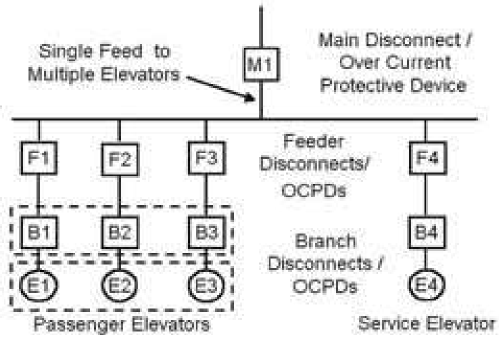


Figure 2

Power Module™

Besides helping in providing a selectively coordinated system, the Power Module™ can simplify the process and ensure consistent practices. There are three disciplines involved in the design, installation, and inspection of elevator systems; this can result in complications and even improper installations. When sprinklers are installed in elevator hoistways, machine rooms, or machinery spaces, ANSI/ASME A17.1 requires that the power be removed to the affected elevator upon or prior to the activation of these sprinklers. The electrical installation allows this requirement to be implemented by a shunt-trip option for the elevator disconnecting means in NEC® 620.51(B). In addition, interface with the fire alarm system along with the monitoring of components required by NFPA 72 must be accomplished in order to activate the shunt trip action when appropriate and as well as making sure that the system is functional during normal operation. This requires the use of interposing relays that must be supplied in an additional enclosure.

Cooper Bussmann® Power Module

Short-Circuit Current Ratings

Background

The 2008 NEC® has a new definition of "short-circuit current rating". Previously there was no definition of short-circuit current rating (sometimes referred to as "withstand rating"), although it was referenced in several sections on the marking and proper application of various types of equipment. Because the term is referenced in multiple locations of the Code, it was necessary to add a definition to Article 100 of the NEC®.

Article 100 Definitions
Short-Circuit Current Rating. The prospective symmetrical fault current at a nominal voltage to which an apparatus or system is able to be connected without sustaining damage exceeding defined acceptance criteria.

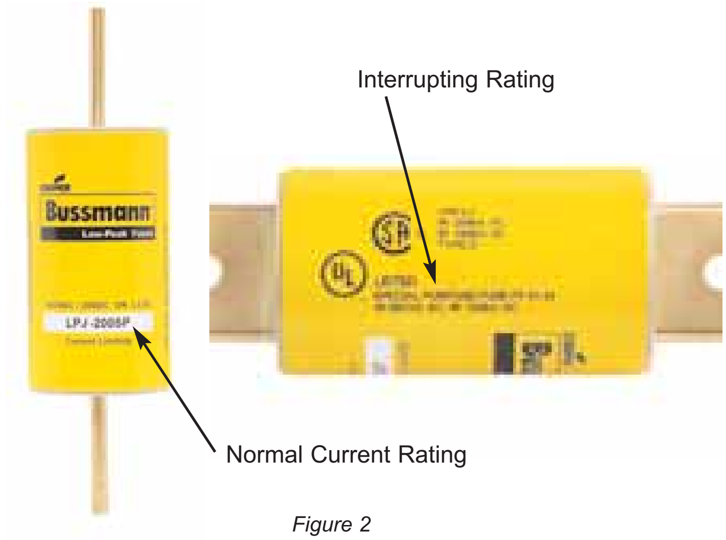


Figure 2

What is Short-Circuit Current Rating?

Short-circuit current rating (SCCR) is the maximum short-circuit current a component or assembly can safely withstand when protected by a specific overcurrent protective device(s) or for a specified time. Adequate short-circuit current rating is required per 110.10.

Figure 1

SCCR: When using (1) gauge wire protected by a (2) ampere maximum Class J fuse. This power distribution block is rated for use on a circuit capable of delivering no more than (3) kA rms sym. or dc amperes 600V maximum. Otherwise 10kA.
Other SCCR options see datasheet.

(1) Wire range	(2) Max. Ampere	(3) SCCR
2-6 AWG	400	200kA
2-14 AWG	200	50kA
2-14 AWG	175	100kA

Figure 1 illustrates a power distribution block that has a default SCCR of 10kA per UL508A SB4 Table SB4.1 However, this PDB has been combination tested and UL Listed with higher SCCRs when in combination with specific types and maximum ampere rating current-limiting fuses. The label is marked with a 200kA SCCR when protected by 400A or less Class J fuses and the conductors on the line side and load side are in the range of 2 to 6 AWG.
For more on Cooper Bussmann® High SCCR PDBs see data sheet 1049.

"Short-circuit current rating" is not the same as "interrupting rating" and the two must not be confused.

Interrupting rating is the maximum short-circuit current an overcurrent protective device can safely interrupt under standard test conditions; it does not ensure protection of the circuit components or equipment. Adequate interrupting rating is required per 110.9. The fuse in Figure 2 has a UL Listed interrupting rating of 300kA at 600Vac or less.

When analyzing assemblies for short-circuit current rating, both the interrupting rating of overcurrent protective devices and the short-circuit current rating of all other components affect the overall equipment short-circuit current rating. For instance, the short-circuit current rating of an industrial control panel typically cannot be greater than the lowest interrupting rating of any fuse or circuit breaker, or the lowest short-circuit current rating of all other compents in the enclosure.

Why is Short-Circuit Current Rating Important?

Short-circuit current ratings provide the level of fault current that a component or piece of equipment can safely withstand (based on a fire and shock hazard external to the enclosure). Without knowing the available fault current and short-circuit current rating, it is impossible to determine if components or equipment can be safely installed.

Specification and installation of new equipment with higher short-circuit current ratings, such as 200,000 amperes, makes it easy to meet the requirements of the NEC®. In addition, when equipment is later moved within a facility or from plant to plant, equipment with the highest ratings can be moved without worrying about unsafe situations that might arise from placing the equipment in a new location where the available short-circuit current is higher than the old location and now above the rating of the equipment.

How to Determine Short-Circuit Current Rating?

For components, the short-circuit current rating is typically determined by product testing. For assemblies, the marking can be determined through the equipment product listing standard or by an approved method. With the release of the UL508A, UL Standard for Safety for Industrial Control Panels, an industry-approved method is now available. UL 508A, Supplement SB, provides an analytical method to determine the short-circuit current rating of an industrial control panel. This method is based upon the weakest link approach. In other words, the assembly marked short-circuit current rating is limited to the lowest rated component short-circuit current rating or the lowest rated overcurrent protective device interrupting rating.

How to Increase Short-Circuit Current Rating?

Protection with current-limiting fuses is the easiest, lowest cost and most effective way to achieve higher short-circuit current ratings. For components, a motor controller can be used to illustrate this point very well. The Cooper Bussmann® compact, non-fused disconnect, the CDNF63, is a Listed UL 508 Manual Motor Controller with a maximum horsepower rating of 40hp at 480V. It is marked with a short-circuit current rating of 5kA when protected by a 150A (or less) Class H fuse or circuit breaker. However, the short-circuit current rating for the CDNF63 is marked 100kA when protected by a 100A (or less) Class J or T fuse (Cooper Bussmann LPJ-110SP or JJS-100).

When using UL 508A Supplement SB, there are significant advantages to using current-limiting fuses in industrial control panels.

1. The high interrupting rating (typically 200kA) of current-limiting fuses increases the ability to achieve higher short-circuit current ratings. If using typical circuit breakers, interrupting ratings are often only 10,000 or 14,000 amperes, which limits the short-circuit current rating of the individual control panel to 10,000 or 14,000 amperes.
2. The use of current-limiting fuses in industrial control panels can also increase component short-circuit current ratings through combination ratings (higher fault current ratings of components when a specific overcurrent protection device is provided). Currently, the only method to achieve high short-circuit current ratings with terminal and power distribution blocks is through the use of current-limiting fuses.
3. If current limiting fuses are used in the feeder circuit of an industrial control panel, the let-through values in UL508A Supplement SB can be used to raise downstream branch circuit component short-circuit current ratings.

What are the Short-Circuit Current Rating Marking Requirements?

The NEC® has requirements for certain components and equipment to be marked with their short-circuit current rating. The important sections of the Code that require the marking of the short-circuit current rating include:

Industrial Control Panels

409.110 requires that an industrial control panel be marked with its short-circuit current rating; see Figure 3.

Figure 3

Industrial Machinery Electrical Panel

670.3(A) requires the nameplate on industrial machinery to include the short-circuit current rating of the machine industrial control panel. In previous editions of the NEC® (2002 Edition) and NFPA 79 (2002 Edition), the industrial machine nameplate was required to include only the interrupting rating of the machine overcurrent protective device, if furnished. This marking was misleading as it did not represent the short-circuit current rating of the machine industrial control panel, but could be misinterpreted as such.

Air Conditioning and Refrigeration Equipment with Multimotor and Combination-Loads

440.4(B) requires the nameplate of this equipment to be marked with its short-circuit current rating. There are three exceptions for which this requirement does not apply: one and two family dwellings, cord and attachment-plug connected equipment, or equipment on a 60A or less branch circuit. So for most commercial and industrial applications, air conditioning and refrigeration equipment with multimotor and combination loads must have the short-circuit current rating marked on the nameplate.

Meter Disconnect Switches (rated up to 600V)

230.82(3) permits a meter disconnect switch ahead of the service disconnecting means, provided the meter disconnect switch has a short-circuit current rating adequate for the available short-circuit current.

Motor Controllers

430.8 requires that motor controllers be marked with their short-circuit current rating. There are three exceptions for fractional horsepower motor controllers, 2 horsepower or less general-purpose motor controllers, and where the short-circuit current rating is marked on the assembly.

How to Assure Compliance?

To assure proper application, the designer, installer, and inspector must assure that the marked short-circuit current rating of a component or equipment is not exceeded by the calculated available fault current.

In order to assure compliance it is necessary to:

- Determine the available short-circuit current or fault current at the point of installation of the component or equipment.
- Assure the component or equipment marked short-circuit current rating is equal to or greater than the available fault current. *(See Figure 4 for example).*

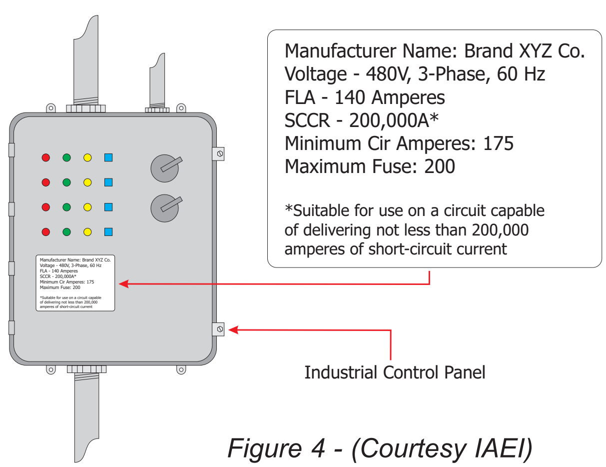


Figure 4 - (Courtesy IAEI)

Any installation where the component or equipment marked short-circuit current rating is less than the available fault current is a lack of compliance and violation of 110.10. In these cases, the equipment cannot be installed until the component or equipment short-circuit current rating is sufficient or the fault current is reduced by an acceptable method.

What Resources are Available?

Cooper Bussmann offers tools to assist with the proper application of short-circuit current ratings including:

Simplified Guide to SCCR – Basic Understanding of short-circuit current ratings and tools to determine the "weakest-link" for industrial control panels.

Advanced Guide to SCCR – In depth discussion of short-circuit current ratings, UL 508A Supplement SB, and how to fix weak-links of industrial control panels.

High SCCR Products

- Current-limiting fuses – high interrupting rating does not limit assembly SCCR and can increase other component ratings within industrial control panels.
- High SCCR Power Distribution and Terminal Blocks – high SCCR is available for feeder circuits (with UL 508A required feeder circuit spacings) and branch circuits. Open and enclosed (IP-20) power distribution blocks.
- Fuse holders, fused disconnects and non-fused disconnects with high SCCR

OSCAR™ (On-Line Short-circuit Current per UL508A Rating Calculator Software) – On-line calculator used to determine and document the short-circuit current rating of industrial control panels.

SPD (Selecting Protective Devices) – Details how to understand, determine and comply with short-circuit current ratings and other overcurrent protection issues.

Short-Circuit Calculator Program – free software download to calculate the available fault current at different points within the electrical distribution system.

Note: There are other companion ratings that must be verified for compliance when installing or inspecting assemblies. These include:

1. **Voltage Rating:** be sure the voltage rating for an assembly is equal to or greater than the system voltage. When devices such as slash rated circuit breakers or motor controllers (ie 480/277) are used, the entire assembly is also limited. Per 240.85 and 430.83(E), a device, which is slash voltage rated, limits the application of that device to only solidly grounded wye systems where the voltage of any conductor to ground does not exceed the lower value and the voltage between any two conductors does not exceed the higher value. Similarly, an entire assembly would have the same limitation, if one or more devices in the assembly were slash voltage rated devices. For instance, if equipment is marked 480/277V due to the use of slash rated motor controllers, it can only be applied on 480/277V (or less) solidly grounded systems. It cannot be applied on 480V ungrounded, impedance grounded, or corner grounded systems.

Article 240 VII. Circuit Breakers
240.85 Applications.
A circuit breaker with a slash voltage rating, such as 120/240V or 480Y/277V, shall be permitted to be applied in a solidly grounded circuit where the nominal voltage of any conductor to ground does not exceed the lower of the two values of the circuit breaker's voltage rating and the nominal voltage between any two conductors does not exceed the higher value of the circuit breaker's voltage rating.

Article 430 VII. Motor Controllers
430.83 Ratings
(E) Voltage Rating.
A controller with slash rating, for example, 120/240 volts or 480Y/277 volts, shall only be applied in a solidly grounded circuit in which the nominal voltage to ground from any conductor does not exceed the lower of the two values of the controller's voltage rating and the nominal voltage between any two conductors does not exceed the higher value of the controller's voltage rating.

2. **Single Pole Interrupting Capability:** Where higher fault currents are present, the single pole interrupting capability of circuit breakers and self-protected combination controllers can be of concern as indicated in the fine print notes of 240.85 and 430.52(C)(6). This is because the single pole interrupting capability is not always equal to the three-pole rating. For instance, a 480V, 100A circuit breaker may have a three pole interrupting rating of 65,000A, but its single pole interrupting capability, based on UL 489 testing requirements, is only 8,660A. This single-pole interrupting capability becomes very critical for ungrounded, corner-grounded, and impedance grounded systems where full voltage can be seen by only one pole of the device.

240.85 (added in 2002 NEC®)
FPN: Proper application of molded case circuit breakers on 3-phase systems, other than solidly grounded wye, particularly on corner, grounded delta systems, considers the circuit breakers' individual pole-interrupting capability.

430.52(C)(6) (added in 2005 NEC®)
FPN: Proper application of self-protected combination controllers on 3-phase systems, other than solidly grounded wye, particularly on corner grounded delta systems, considers the self-protected combination controllers' individual pole-interrupting capability.

Other Considerations

Applying components or equipment within their short-circuit current rating does not mean the components can not sustain damage. UL Standards have evaluation criteria for acceptance to SCCR testing. Components and assemblies are tested in an enclosure with the bolted short-circuits external to the enclosure and door closed or cover fastened. The typical evaluation acceptance criteria by UL is

- The enclosure cannot become energized (shock hazard)
- The door or cover cannot blow open and there cannot be any large holes in the enclosure (fire hazard external to the enclosure). However, extensive damage may be permitted to the internal components.

Applying components or equipment within their short-circuit current rating, does not mean the equipment does not pose an arc flash hazard. Equipment certification tests are not run with arcing faults inside the enclosure. An arcing fault within a closed enclosure is a potentially serious hazard with the doors closed or open; incidents have been reported of doors being blown open, or off, due to arcing faults. A marked short-circuit current rating for an assembly does not signify that someone working on or near energized equipment will be uninjured if an arcing fault occurs with the doors either open or closed and latched.

Branch-Circuit Overcurrent Devices

Background

A definition for branch-circuit overcurrent device has been added to the 2008 edition of the National Electrical Code® to provide clarity to users of the Code as to what the devices are and how they can be used.

New Definition

NEC® Article 100
Branch-Circuit Overcurrent Device. A device capable of providing protection for service, feeder, and branch circuits and equipment over the full range of overcurrents between it's rated current and it's interrupting rating. Branch-circuit overcurrent protective devices are provided with interrupting ratings appropriate for the intended use but no less than 5,000 amperes.

With the added definition for 2008, it becomes clear that a branch-circuit overcurrent protective device is suitable for use at any point in the electrical system to protect branch circuits, as well as feeder circuits and mains. The definition also illustrates that a branch-circuit overcurrent device must be capable of protecting against the full range of overcurrents which includes overloads and short-circuits as well as have an interrupting rating sufficient for the application (this reflects the interrupting rating requirements of 110.9). In addition to the traits described in the new definition, branch-circuit overcurrent devices meet minimum common standardized requirements for spacings and operating time-current characteristics.

Overcurrent protective device types fall into two main categories; "Branch-circuit overcurrent devices" and "Application-limited" devices. Table 1 lists acceptable branch-circuit overcurrent device types along with Cooper Bussmann branch-circuit fuse part numbers. These devices meet the new NEC® definition.

Branch-Circuit Fuses

Table 1

Device Type	Acceptable Devices	Cooper Bussmann® Branch-Circuit Fuses
UL 248 Fuses	Class J Fuse	LPJ_SP, JKS, DFJ*
	Class RK1 Fuse	LPN-RK_SP, LPS-RK_SP
	Class RK5 Fuse	FRN-R, FRS-R
	Class T Fuse	JJN, JJS
	Class CC Fuse	LP-CC, KTK-R, FNQ-R
	Class L Fuse	KRP-C_SP, KLU, KTU
	Class G Fuse	SC
	Class K5 Fuse	NON, NOS (0-60A)
	Class H Fuse	NON, NOS (61-600A)
UL 489 Circuit Breakers	Molded Case CBs, Insulated Case CBs	
UL 1066 Circuit Breakers	Low Voltage Power CBs	

*DFJ fuse listed as Class J and provides high speed fuse protection

Application-limited devices all have some limitations that restrict their usage. The NEC® permits some devices for specific branch-circuit applications under limited conditions. Other devices, such as supplementary overcurrent devices, can never be used as branch-circuit overcurrent protection. When applied both categories must have an adequate interrupting rating (NEC® 110.9) and must protect the circuit components (NEC® 110.10). The two categories are further summarized with the following:

(1) **Permitted for specific branch circuit applications under limited conditions per the specific reference in the NEC®:** These OCPDs have some limitation(s) and are not true branch-circuit devices but may be permitted if qualified for the use in question. For example, most high speed fuses are not branch circuit OCPDs, however high speed fuses are allowed to be used for short circuit protection on motor circuits utilizing power electronic devices by 430.52(C)(5). Motor Circuit Protectors (MCP) are recognized devices (not listed) and can be used with the intent of providing short circuit protection for motor branch circuits, if used in combination with a listed combination starter for which the MCP has been tested and recognized by a NRTL (per 430.52(C)(3)). Both of these examples are only suitable for use on motor branch circuits, they cannot be used on other branch-circuit types or for service or feeder protection. Special attention must be paid to the circuit type, NEC® requirements, and the devices in question when considering the use of application specific devices.

Branch-Circuit Overcurrent Devices

In other words these types of overcurrent devices are only acceptable for use under special conditions.

(2) **Supplementary overcurrent protective devices:** These devices have limited applications which are discussed further on the next page but must always be in compliance with 240.10. The definition for supplementary overcurrent protective device was added to the 2005 NEC®.

Application Limited Devices	
High Speed Fuses[1]	Supplementary Fuses[4]
Motor Circuit Protector[2]	Limiters[5]
Self Protected Starter[3]	UL 1077 Protectors[4]

1. HS Fuses w/ marked replacement per 430.52(C)(5)
2. MCP if part of listed combination starter per 430.52(C)(3)
3. SPS if listed as self protected combination controller per 430.52(C)(6)
4. Supplementary protection per 240.10
5. Cable Limiters per 230.82

The use of supplementary overcurrent protective devices allowed by 240.10 is for applications such as lighting and appliances shown in Figure 1. The supplementary protection is in addition to the branch-circuit overcurrent protection provided by the device protecting the branch circuit (located in the lighting panel in Figure 1).

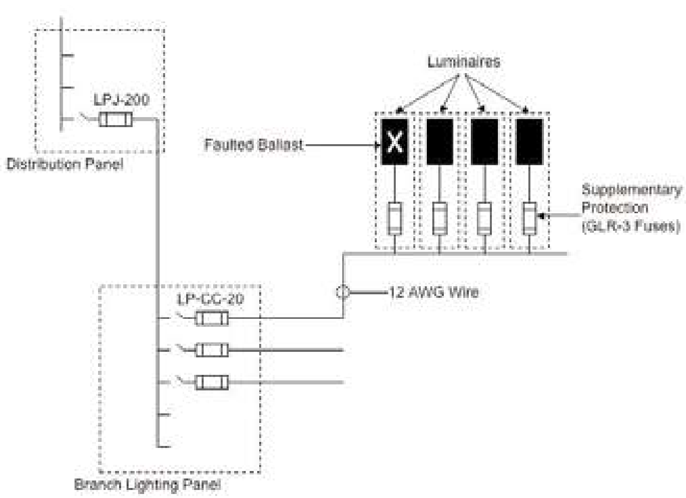


Figure 1

Branch circuit overcurrent protective devices can also be used to provide the additional protection that a supplementary overcurrent protective device provides: see Figure 2. Rather than using a supplementary overcurrent protective device for supplementary protection of the luminaire, a branch-circuit overcurrent protective device is used. The fact that a branch-circuit overcurrent device is used where a supplementary device is permitted does not turn the circuit between the lighting panel and the fixture from a branch-circuit to a feeder. In the case of Figure 2, the branch circuit starts on the loadside of the 20A fuse in the lighting panel.

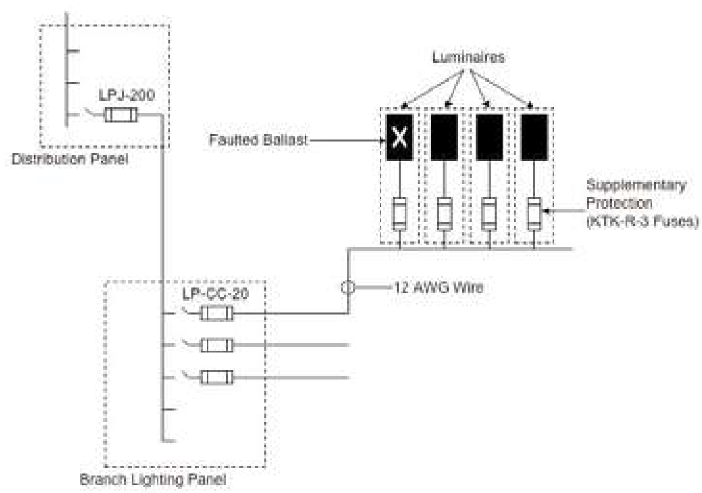


Figure 2

How to Comply

It is vital to know how a device is listed to its respective product standard. If listed as a branch-circuit overcurrent device it is easier to apply. For circuits where the overcurrent protective device is one shown in Table 1, the device suitability as a branch-circuit overcurrent protective device is not in question. So if the overcurrent device is an LPJ-SP fuse for example, or a listed UL 489 Circuit Breaker, it is permissible for overload and short-circuit protection on any service, feeder or branch-circuit where properly applied. Other types of protective devices have to be qualified for the use in question. Caution should always be used to assure that the proper overcurrent device is being used for the application at hand. Cooper Bussmann publication SPD-Selecting Protective Devices has a section titled “Devices for Motor Circuits” that discusses the listing for various devices and how they can be applied.

Supplementary Overcurrent Protective Devices

Background

A definition for "Supplementary overcurrent protective device" was added into Article 100 for the 2005 NEC®. The definition was added to help avoid serious misapplication of devices that may have limitations for general usage. Supplementary protective devices can only be used as additional protection when installed on the load side of a branch-circuit overcurrent device. Supplementary devices must not be applied where branch-circuit overcurrent protective devices are required; unfortunately this unsafe misapplication is prevalent in the industry. Supplementary devices are properly used in some appliance applications and where branch-circuit overcurrent protection is not needed.

NEC® Article 100
Supplementary Overcurrent Protective Device.
A device intended to provide limited overcurrent protection for specific applications and utilization equipment such as luminaires (lighting fixtures) and appliances. This limited protection is in addition to the protection provided in the required branch circuit by the branch-circuit overcurrent protective device.

Supplementary overcurrent protective devices are not general use devices, as are branch-circuit overcurrent devices, and must be evaluated for appropriate application in every instance where they are used. Supplementary overcurrent protective devices are extremely application oriented and prior to applying the devices, the differences and limitations for these devices must be investigated and found acceptable.

Examples of supplementary overcurrent protective devices include, but are not limited to the following:

UL248-14
Supplemental Fuses

UL1077 Supplemental
Protectors (Mini Circuit Breakers)

One example of the difference and limitations is that a supplementary overcurrent protective device may have creepage and clearance spacings that are considerably less than that of a branch-circuit overcurrent protective device.

Example:
- A supplementary protector, UL1077, has spacings that are ⅜ inch through air and ½ inch over surface at 480V.
- A branch-circuit rated UL489 molded case circuit breaker has spacings that are 1 inch through air and 2 inches over surface at 480V.

Another example of differences and limitations is that branch-circuit overcurrent protective devices have standard overload characteristics to protect branch-circuit, feeder, and service entrance conductors. Supplementary overcurrent protective devices do not have standard overload (time-current) characteristics and may differ from the standard branch-circuit overload characteristics. Also, supplementary overcurrent protective devices have interrupting ratings that can range from 32 amps to 100,000 amps. When supplementary overcurrent protective devices are considered for proper use, it is important to be sure that the device's interrupting rating equals or exceeds the available short-circuit current and that the device has the proper voltage rating for the installation (including compliance with slash voltage rating requirements, if applicable).

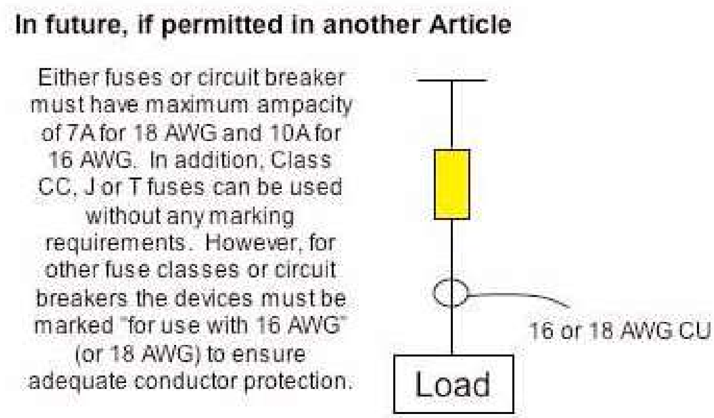
Reasons Why Supplementary Protectors (UL1077 Devices) can not be used to Provide Branch-Circuit Protection

1. Supplementary Protectors are not intended to be used or evaluated for branch-circuit protection in UL1077
2. Supplementary protectors have drastically reduced spacings, compared to branch-circuit protective devices, and depend upon the aid of a separate branch circuit protective device upstream
3. Supplementary protectors do not have standard calibration limits or overload characteristics performance levels and cannot assure proper protection of branch-circuits
4. Multipole supplementary protectors for use in 3 phase systems are not evaluated for protection against all types of overcurrents
5. Most supplementary protectors are short-circuit tested with a branch-circuit overcurrent device ahead of them and rely upon this device for proper performance
6. Supplementary protectors are not required to be tested for closing into a fault
7. Recalibration of a supplementary protector is not required and depends upon manufacturer's preference. There is no assurance of performance following a fault or resettability of the device.
8. Considerable damage to a supplemental protector is allowed following short-circuit testing.
9. Supplementary protectors are not intended be used as a disconnecting means.
10. Supplementary protectors are not evaluated for short circuit performance criteria, such as energy let through limits or protection of test circuit conductors

Protection of Small Conductors

Background

Up until now, 14 AWG was the smallest branch-circuit conductor allowed for general building systems use in the NEC®. 2008 NEC® added requirements for overcurrent protection of 16 and 18 AWG CU insulated conductors for power circuits in 240.4(D). This action in itself does not permit the use of these smaller conductors; it provides the criteria for the proper overcurrent protection if other articles of the NEC® permit these smaller conductors for the circuits/equipment covered by a given article.



Requirement

240.4(D) Small Conductors. Unless specifically permitted in 240.4(E) or (G), the overcurrent protection shall not exceed that required by (D)(1) through (D)(7) after any correction factors for ambient temperature and number of conductors have been applied.

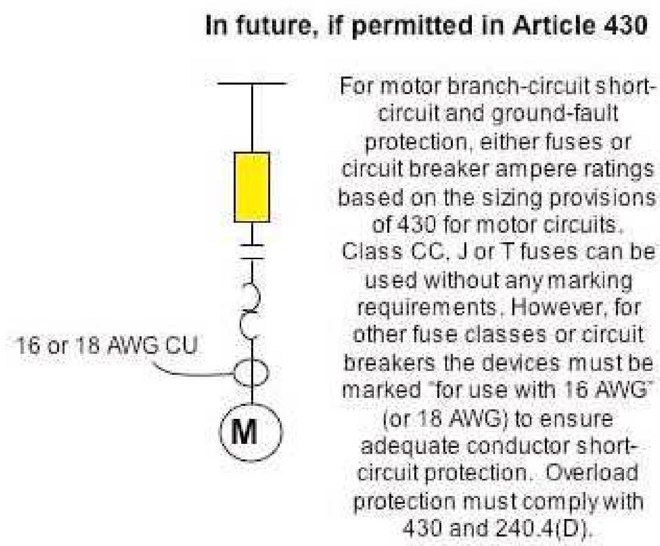
(1) 18 AWG Copper. 7 amperes, provided all the following conditions are met:

(1) Continuous loads do not exceed 5.6 amperes
(2) Overcurrent protection is provided by one of the following:
- a. Branch-circuit rated circuit breakers listed and marked for use with 18 AWG copper wire
- b. Branch-circuit rated fuses listed and marked for use with 18 AWG copper wire
- c. Class CC, Class J, or Class T fuses

(2) 16 AWG Copper. 10 amperes, provided all the following conditions are met:

(1) Continuous loads do not exceed 8 amperes
(2) Overcurrent protection is provided by one of the following:
- a. Branch-circuit rated circuit breakers listed and marked for use with 16 AWG copper wire
- b. Branch-circuit rated fuses listed and marked for use with 16 AWG copper wire
- c. Class CC, Class J, or Class T fuses

(3) 14 AWG Copper. 15 amperes
(4) 12 AWG Aluminum and Copper-Clad Aluminum. 15 amperes
(5) 12 AWG Copper. 20 amperes
(6) 10 AWG Aluminum and Copper-Clad Aluminum. 25 amperes
(7) 10 AWG Copper. 30 amperes



Why

Short-circuit currents can quickly damage insulated conductors. The level of damage can vary from slight insulation damage, to annealing of the copper, to vaporization of the copper. Under short circuit conditions the level of damage sustained is a factor of a specific insulated conductor's withstand capability, the level of short-circuit current, and the time the short-circuit current is permitted to flow. Smaller conductors such as 16 AWG and 18 AWG have very low short circuit current withstands and in many instances, the generally acceptable overcurrent protective devices do not have the operating characteristics to provide adequate protection as required in 110.10.

Small Wire Report

In August, 2001 there was an investigation by the Small Wire Working Group of the NFPA 79 Electrical Standard for Industrial Machinery. The investigation focused on the protection of 16 and 18 AWG CU conductors for use in Industrial Machinery applications and resulted in similar requirements as 240.4(D). The basis of this study compared the conductor short-circuit current withstand to the overcurrent device let-through energy under short-circuit conditions. The Small Wire Working Group studied the critical application considerations for small conductors, proposed the requirements and conducted UL witnessed tests to prove the proposed requirements are acceptable. After considering several damage criteria, the group decided to use the ICEA damage levels because they were the most conservative. All other methods allowed certain levels of damage. A testing program with insulation damage evaluation criteria was conducted to prove the engineering analysis as valid. This study determined that small conductors could be sufficiently protected by certain overcurrent protective devices, but not all the standard commercially available overcurrent protective devices provided acceptable levels of protection.

In this study, Class CC, J and T fuses, 30A and smaller, were found to provide short-circuit protection for these conductors. The very current limiting characteristics of these fuses provide the necessary level of protection under short-circuit conditions. For Class CC, J, or T fuses, the maximum short-circuit current energy permitted by UL for the 30A or less ampere ratings is below the ICEA thermal energy damage criteria. In the testing, special fuse limiters that purposely exceed the short-circuit current I^2t umbrella limits for the applicable class fuses from UL 248 Fuse Standard were tested with 16 and 18 AWG CU insulated conductors. After the tests, the insulated conductors were evaluated by a set criteria including dielectric testing. The conclusion was that Class CC, J and T 30A or less fuses protect 16 and 18 AWG CU insulated conductors simply by complying with UL 248 performance required for listing and follow-up testing. The UL 248 30A or less Class CC, J, and T fuse let-thru energy limits are less than the 16 or 18 AWG CU insulated conductor ICEA withstands. See Table Below.

ICEA I2t Withstand Limit CU Conductor Thermoplastic Insulation (75ºC)		UL 248 I^2t Let-Thru Limits for 30A Class CC, J, Fuses
CU Wire Size	Short-Circuit I^2t Withstand	
16 AWG	7,344 A^2s	7000A^2s (value for 50kA, 100kA, and 200kA)
18 AWG	18,657 A^2s	
Conclusion: All commercially available fuses of 30A or less of these fuse types will provide short-circuit protection for 16 and 18 AWG CU insulated conductors		

Note to Table: all commercially available UL Class CC, J, and T 30A or less fuses can protect these conductors from short-circuit currents. However, the actual maximum ampere rating permitted for a given application is restricted by the applicable NEC® requirements.

As important, the study confirmed that many other overcurrent protective devices do not provide the necessary level of protection. Therefore, fuses, other than Class CC, J, or T fuses, and circuit breakers are required to be marked "for use with 16AWG" or "for use with 18AWG". In essence, this means other fuses and all circuit breakers are required to be tested under a specific criteria for small wire and if pass, then listed and marked as such. UL issued a Special Service Investigation, An Investigation of the use of 16 and 18 AWG Conductors for Power Branch Circuits in Industrial Machinery Applications, file number E4273 to verify the test results. The analysis, test program and results can also be viewed in an IEEE paper presented at the 2002 IEEE Industrial and Commercial Power Systems Technical Conference titled, An Investigation of the Use of 16 and 18 AWG Conductors for Branch-Circuits in Industrial Machinery Built to NFPA 79 2002.

back down, a drain valve at the bottom of the piston is opened by a solenoid valve and as the fluid drains back into the reservoir, the elevator lowers. If the main line power is lost, this battery pack attachment can supply enough power to actuate the solenoid.

For the battery backup feature to operate properly, auxiliary contacts need to be in the controller and the disconnecting means. In addition, the disconnect/overcurrent protection in conjunction with the auxiliary contact must function properly for various operating scenarios. See Figure 3 has an illustrative diagram. A complete explanation of the various operating scenarios can not be presented in this publication.

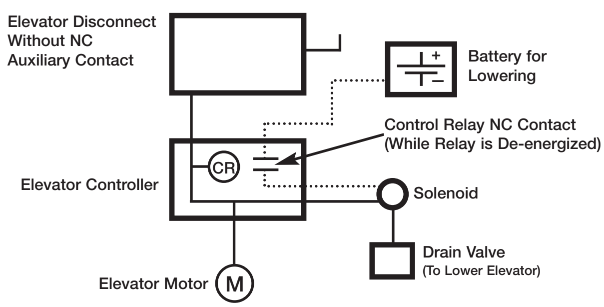


Figure 3 Normal Operation per NEC® 620.91(C) – this complies

It is important to recognize that the type disconnect used for the elevator shunt-trip device has a direct bearing on whether the battery backup functions as intended and whether the systems complies with 620.91(C). If not, there may be a safety hazard. There typically are three options considered for shunt-trip elevator disconnects with integral auxiliary contacts. Only one of these three work properly for elevators with battery backup for all scenerios:

1. Fusible shunt-trip switch with auxiliary contacts – (Cooper Bussmann Power Module™)
2. Fusible shunt-trip molded case switch (with an instanta neous trip override) with auxiliary contacts
3. Shunt-trip molded case circuit breaker with auxiliary contacts

Only the first option, the fusible shunt-trip switch with auxiliary contacts, provides the proper functioning if there is an overcurrent that opens one or more fuses in the disconnect. In this case the fuse(s) open resulting in a loss of power for one or more phases, but the auxiliary contacts in the disconnect do not change state. So the battery backup function can work as intended.

For options 2 and 3, a branch circuit overcurrent that causes them to open may open the auxiliary contact and not allow battery backup to function as intended, which may be a safety issue. The molded case switch, option 2, has an instantaneous trip override that operates at a certain overcurrent level and beyond. When such an overcurrent occurs, the switch opens and the auxiliary contact opens. So for an overcurrent condition with option 2, the fusible molded case switch, may open and battery backup does not operate as intended. Whenever the molded case breaker, option 3, clears an overcurrent, the circuit opens and the auxiliary contact opens. Option 1 is the only option that properly operates and doesn't strand passengers.

The POWER MODULE™ contains a shunt trip fusible switch together with the components necessary to comply with the fire alarm system requirements and shunt trip control power all in one UL Listed package. For engineering consultants this means a simplified specification. For contractors this means a simplified installation because all that has to be done is connecting the appropriate wires. For inspectors this becomes simplified because everything is in one place with the same wiring every time. The fusible portion of the switch utilizes LOW-PEAK® LPJ-(amp)SP fuses that protect the elevator branch circuit from the damaging effects of short-circuit currents as well as helping to provide an easy method of selective coordination when supplied with upstream LOW-PEAK fuses with at least a 2:1 amp rating ratio. Note the POWER MODULE™ only accepts Class J fuses which have a physical size rejection feature (only Class J fuses accepted) and Class J fuses have 200,000A or 300,000A interrupting rating.

Cooper Bussmann® Fuse Cross Reference & Low-Peak® Upgrade

The left column represents Cooper Bussmann and competitors' part numbers. The right column represents the Cooper Bussmann upgrades.

The Cooper Bussmann® fuse upgrade offers superior performance while reducing the number of SKUs that need to be in stock. Low-Peak® fuses feature a high degree of current limitation, which will provide the best component protection and may reduce the arc-flash hazard. Listings are alpha-numerical by fuse class and fuse catalog symbol.

This list is only a consolidated cross reference to some of our most common products. For a much more extensive database please consult the ***Product Profiler*** competitor cross-reference.

Class CC and Midget

Existing Fuse	Low-Peak® Upgrade
A6Y (type 2B)	LP-CC
ABU	
AGU	
ATDR	
ATM	
ATMR	
ATQ	
BAF	
BAN	
BLF	
BLN	
CCMR	
CM	
CMF	
CNM	
CNQ	
CTK	
CTK-R	
FLM	
FLQ	
FNM	
FNQ	
GGU	
HCLR	
KLK	
KLK-R	
KTK	
KTK-R	
MCL	
MEN	
MEQ	
MOF	
MOL	
OTM	
TRM	
6JX	LP-CC
***FNQ-R suggested on primary of control transformers.**	
ATQR	
FNQ-R	FNQ-R
KLDR	

Class J

Existing Fuse	Low-Peak® Upgrade
A4J	LPJ_SP
AJT	
CJ	
CJS	
GF8B	
HRCXXJ	
J	
JA	
JCL	
JDL	
JFL	
JHC	
JKS	
JLS	
JTD	LPJ_SP

Class L

Existing Fuse	Low-Peak® Upgrade
A4BQ	KRP-C_SP
A4BT	
A4BY	
A4BY (type 55)	
CLASS L	
CLF	
CLL	
CLU	
HRC-L	
KLLU	
KLPC	
KLU	
KTU	
L	
LCL	
LCU	KRP-C_SP

250 Volt Class R

Existing Fuse	Low-Peak® Upgrade
A2D	LPN-RK_SP
A2D-R	
A2K	
A2K-R	
A2Y (type 1)	
AT-DE	
CHG	
CRN-R (type 3)	
CTN-R	
DEN	
DLN	
DLN-R	
ECN	
ECN-R	
ERN	
FLN	
FLN-R	
FRN	
FRN-R	
FTN-R	
GDN	
HAC-R	
HB	
KLN-R	
KON	
KTN-R	
LENRK	
LKN	
LLN-RK	
LON-RK	
NCLR	
NLN	
NON	
NRN	
OTN	
REN	
RFN	
RHN	
RLN	
TR	
655	
660	
10KOTN	
50KOTN	LPN-RK_SP

600 Volt Class R

Existing Fuse	Low-Peak® Upgrade
A6D	LPS-RK_SP
A6K-R	
A6X (type 1)	
ATS-DE	
CHR	
CTS-R	
DES	
DES-R	
DLS	
DLS-R	
ECS-R	
ERS	
FLS	
FLS-R	
FRS	
FRS-R	
FTS-R	
GDS	
HA	
KLS-R	
KOS	
KTS-R	
LES	
LES-R	
LES-RK	
LKS	
LLS-RK	
LOS-RK	
NLS	
NOS	
NRS	
OTS	
RES	
RFS	
RHS	
RLS	
SCLR	
TRS	
TRS-R	
656	
10KOTS	
50KOTS	LPS-RK_SP

The comparative catalog numbers shown were derived from the latest available published information from various manufacturers. Because competitors' products may differ from Cooper Bussmann products, it is recommended that each application be checked for required electrical and mechanical characteristics before substitutions are made. Cooper Bussmann is not responsible for misapplications of our products. Overcurrent protection is application dependent.

Low-Peak™ LPJ Class J 600Vac/300Vdc, 1-60A, dual element, time-delay fuses

RoHS

Available with *easy*ID™ open fuse indication

Catalog symbol:

- LPJ-(amp)SP (non-indicating)
- LPJ-(amp)SPI (indicating)

Description:

Bussmann® series Ultimate protection LPJ Class J dual element, current-limiting, time-delay fuses available with optional open fuse indication. Time-delay – 10 seconds (minimum) at 500% of rated current.

Specifications:

Ratings

- Volts
  - 600Vac
  - 300Vdc*
- Amps 1-60A
- IR
  - 300kA Vac RMS Sym.
  - 100kA Vdc

* Indicating versions not Vdc rated.

Agency information

- UL® Listed, Guide JDDZ, File E4273
- CSA® Certified, Class 1422-02, File 53787, Class J per CSA 22.2 No. 248.
- CE
- RoHS compliant

Catalog numbers (amps) – non-indicating fuses

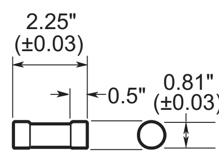
LPJ-1SP	LPJ-3SP	LPJ-7SP*	LPJ-25SP*
LPJ-1-1/4SP	LPJ-3-2/10SP	LPJ-8SP*	LPJ-30SP*
LPJ-1-6/10SP	LPJ-3-1/2SP	LPJ-9SP*	LPJ-35SP*
LPJ-1-8/10SP	LPJ-4SP	LPJ-10SP*	LPJ-40SP*
LPJ-2SP	LPJ-4-1/2SP	LPJ-12SP*	LPJ-45SP*
LPJ-2-1/4SP	LPJ-5SP	LPJ-15SP*	LPJ-50SP*
LPJ-2-1/2SP	LPJ-5-6/10SP	LPJ-17-1/2SP*	LPJ-60SP*
LPJ-2-8/10SP	LPJ-6SP*	LPJ-20SP*	

* Open fuse indication available by inserting the suffix "I," e.g., LPJ-15SPI. Requires 75Vac minimum voltage. Indicating fuses are not Vdc rated.

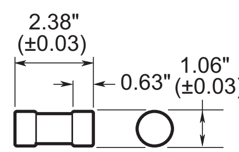
Carton quantity:

Amp rating	Carton qty.
1–60	10

Dimensions - in



1 to 30A



35 to 60A

Features:

- Industry's only UL Listed and CSA Certified fuse with a 300kA interrupting rating that allows for simple, worry-free installation in virtually any application.
- Fast short-circuit protection and dual-element, time-delay performance provide ultimate protection.
- Reduces existing fuse inventory by up to 33% when upgrading to Low-Peak fuses.
- Consistent 2:1 ampacity ratios for all Low-Peak fuses make selective coordination easy.
- Long time-delay minimizes needless fuse openings due to temporary overloads and transient surges.
- Current-limitation protects downstream components against damaging thermal and magnetic effects of short-circuit currents.
- Dual-element fuses have lower resistance than ordinary fuses so they run cooler. They can often be sized for back-up protection against motor burnout from overload or single-phasing if other overload protective devices fail.
- Proper sizing can provide "no damage" Type 2 coordinated protection for NEMA® and IEC® motor controllers.
- Space-saving package for equipment downsizing.

Recommended fuse blocks and holders:

Fuse amps	1-Pole	2-Pole	3-Pole
Modular open blocks with optional covers			
0-30	JM60030-1_	JM60030-2_	JM60030-3_
35-60	JM60060-1_	JM60060-2_	JM60060-3_
"Pyramid" blocks			
0-30	—	—	JP60030-3_
CH holders			
0-30	CH30J1_	CH30J2_	CH30J3_
35-60	CH60J1_	CH60J2_	CH60J3_
Safety J™ holders			
0-30	JT60030_	—	—
35-60	JT60060_	—	—

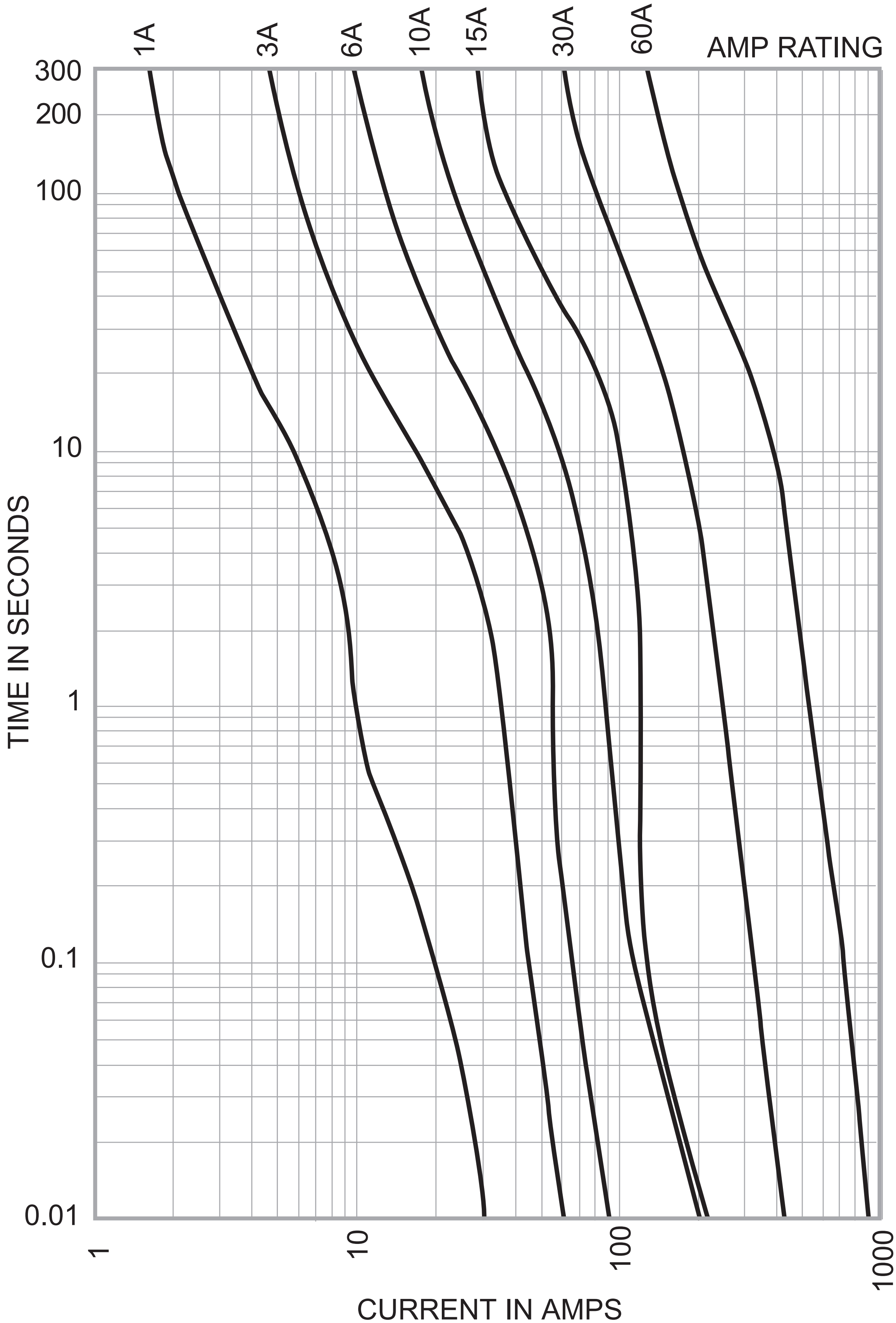
For additional information on the Class J fuse blocks and holders, see data sheets no. 10289 (modular open blocks), no.1108 (pyramid blocks), no. 2144 (CH) and no. 1152 (Safety J).

Fuse reducers for Class J fuses:

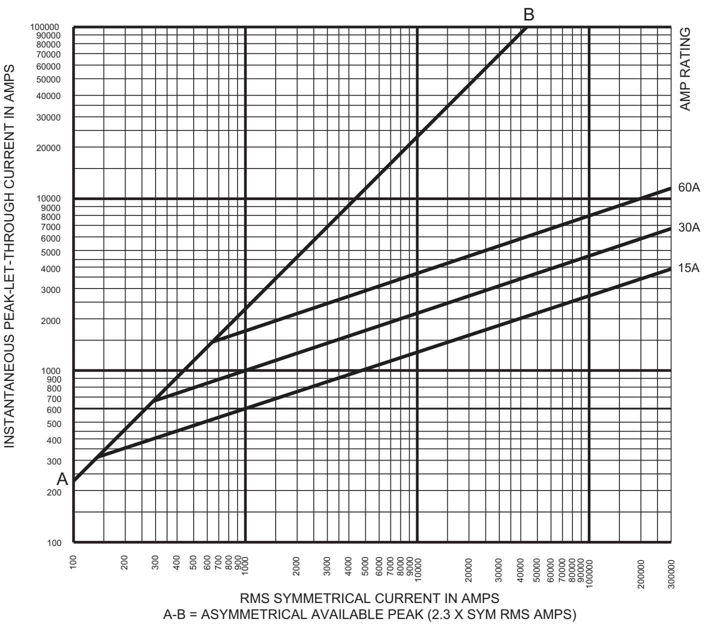
Equipment fuse clips	Desired fuse (case) size	Catalog numbers (pairs)
60A	30A	J-63
100A	30A	J-13
	60A	J-16
200A	60A	J-26†

† Not for bolt-in applications.

Time-current curves - average melt



Current-limitation curves:



Current-limiting effects:

Prospective S.C.C.	Let-through current (apparent RMS symmetrical vs. fuse rating)		
	15A	30A	60A
1000	1000	1000	1000
3000	1000	1000	1000
5000	1000	1000	1000
10,000	1000	1000	2000
15,000	1000	1000	2000
20,000	1000	1000	2000
25,000	1000	1000	2000
30,000	1000	1000	2000
35,000	1000	1000	2000
40,000	1000	2000	3000
50,000	1000	2000	3000
60,000	1000	2000	3000
80,000	1000	2000	3000
100,000	1000	2000	4000
150,000	1000	2000	4000
200,000	2000	3000	4000
250,000	2000	3000	5000
300,000	2000	3000	5000

Fuses Made Simple™

BUSSMANN SERIES

The easiest and fastest way to select and specify the right fuse

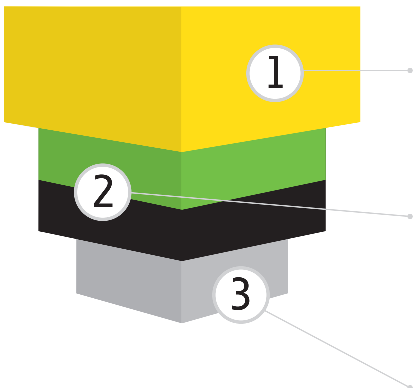
EATON

Powering Business Worldwide

Fuse selection
made simple

Fuses Made Simple™ with Bussmann™ series fuses

Three tiers of protection help speed up specification and selection



Each tier of protection offers distinct levels of performance benefits.

Ulitimate protection – The best worry-free protection in virtually any application. Unique dual-element construction delivers a powerful combination of all performance options in one fuse - fast short-circuit protection, current limitation, and time-delay performance with up to 300 kA interrupting ratings.

Advanced protection – Application specific protection for sensitive devices and critical components or motors and transformers. Choose between fast short-circuit, current limiting performance or energy efficient, current limiting, time-delay performance based on the application. Featuring 200 kA interrupting ratings.

Basic protection – Basic single-element protection for service, feeder and branch circuit applications. Featuring up to 100 kA interrupting ratings.

Four fuse families make fuse selection and replacement easy

Each fuse family is categorized by key protection characteristic and performance benefits.

Ulitimate protection

- Low-Peak™ (yellow) - 50% more protection than any other listed fuse*

Advanced protection

- Fusetron™ (green) - 23% more energy efficient*** and the best time-delay performance
- Limitron™ (black) - 10x better current limitation than basic circuit breakers or fuses**

Basic protection

- General purpose (gray) - Basic circuit protection

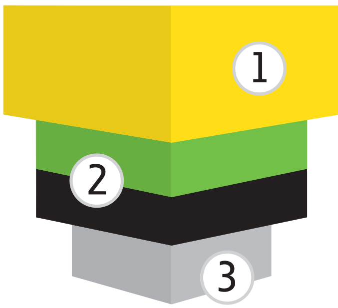
QuikShip™ Service - get the fuse you need, when you need it

- The Bussmann series QuikShip Everyday Service assures the most common part numbers are in stock and ship within 24 hours. In fact, 90% of our orders are shipped the same day.
- Emergency and after-hours orders are possible with Bussmann series QuikShip Emergency Service.

* 50% higher IR (300kA) than any other UL and CSA Listed Fuse. Includes Class J, L and R fuses.
** Does not include current limiting circuit breakers or current limiting fuses. Protection determined by comparing published values for let–through for Class CC, J, R, and T fuses versus a symmetrical RMS waveform at 200kA.
*** Test results are based on weighted sales volume of FUSETRON and Ferraz Shawmut (Mersen) fuses by selected amp and volt rating combination. Next leading brand refers to Ferraz Shawmut based on third-party fuse market share data for a twenty-seven month period (July 2008 through September 2010).

Three tiers of protection

Follow the **tiers of protection** to find the right level of protection for your application



The four **Fuses Made Simple** families are grouped into three tiers of protection to meet the needs of any application.

When you move up to the next level of protection, you can get enhanced performance compared to the fuses in the lower tier. For example, Fusetron fuses can replace your general purpose fuses in branch circuit applications and Low-Peak can be used in any application, giving you worry free, enhanced performance.

	LOW-PEAK™	FUSETRON™	LIMITRON™	GENERAL
1 Ultimate protection				
Industry's only UL® and CSA® listed fuse with up to 300 kA interrupting rating	✓			
Combines Limitron fast short-circuit protection and Fusetron dual-element time-delay for ultimate protection	✓			
Best in class Arc Flash Protection in all applications reduces hazard to personnel	✓			
Reduce inventory up to 33% by replacing General Purpose, Limitron, and Fusetron with Low-Peak fuses	✓			
Consistent 2:1 selective coordination ratios for all Low-Peak fuses	✓			
2 Advanced protection				
Dual-element time-delay allows for superior protection of motors and transformers	✓	✓		
23% more energy efficient than the next leading brand***	✓	✓		
Best time-delay performance	✓	✓		
200 kA interrupting rating allows for use in virtually any application	✓	✓	✓	
Fast short-circuit protection of critical devices or loads	✓		✓	
Arc flash protection in selected applications reduces hazard to personnel	✓		✓	
10x better current limitation on average compared to basic circuit breakers and fuses**	✓		✓	
3 Basic protection				
Meets basic requirements for service, feeder, and branch circuit protection	✓	✓	✓	✓

Four fuse families

Low-Peak

Delivers 50% more protection than any other listed fuse*
Ultimate protection for any application

- Industry's only UL and CSA listed fuse with a 300 kA interrupting rating allows for simple, worry-free installation in virtually any application
- Fast short-circuit protection and dual element, time-delay performance for ultimate protection
- Consistent 2:1 coordination ratios for all Low-Peak fuses make selective coordination easy
- Broad fuse family including Class CC, J, L, and R

Fusetron

23% More Energy Efficient* and the Best Time-Delay Performance*****
Advanced protection and save more money

- FUSETRON fuses are on average 23% more energy efficient than the next leadingbrand**
- Dual-element feature provides the best time-delay performance
- Allows for closer sizing to load and better equipment protection
- Ideal for protection of motors and transformers
- Class RK5 fuses with 200 kA interrupting rating

Limitron

10x better current limitation than basic circuit breakers or fuses**
Advanced protection for sensitive devices and critical components

- Provides short circuit protection that is on average 10x faster than basic circuit breakers or fuses**
- Fast-acting fuses help prevent equipment damage caused by short-circuit events
- Ideal for critical components in industrial or commercial applications
- Class CC, J, L, R and T fuses with 200 kA interrupting rating

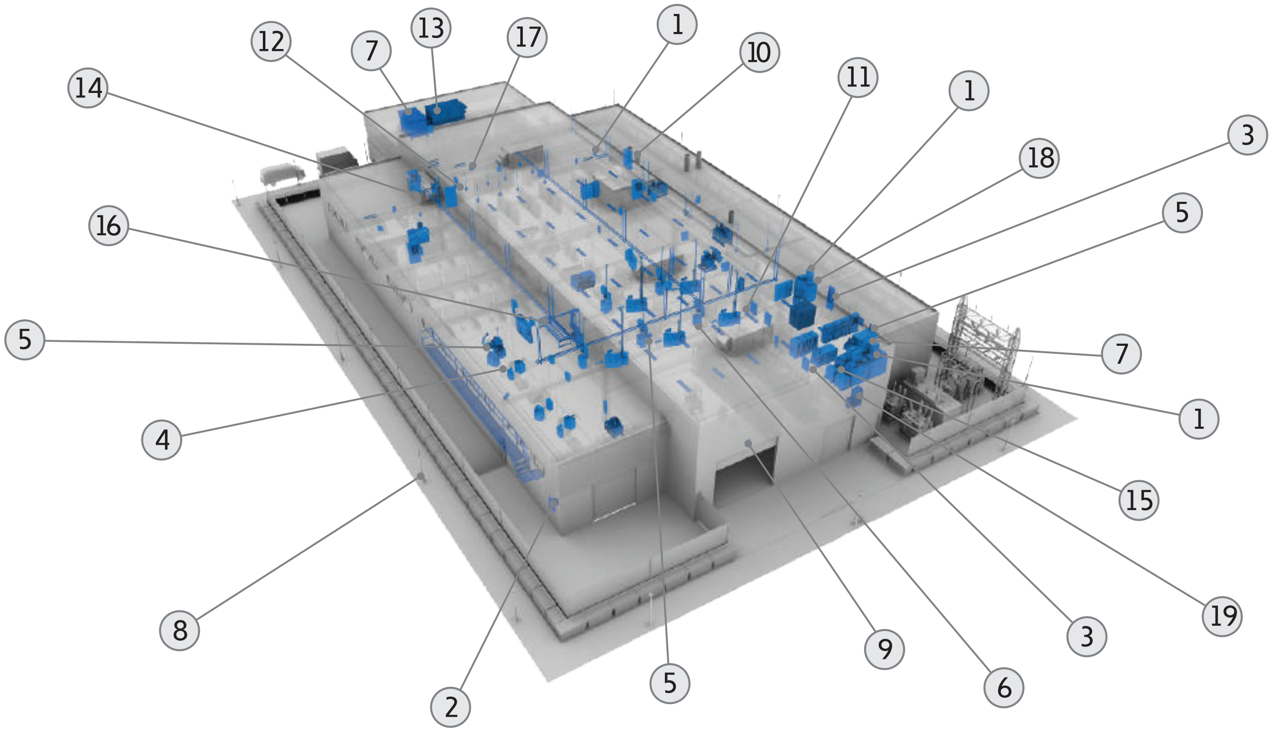
General purpose

Basic circuit protection
Basic overcurrent protection

- Meets basic NEC®, CEC, UL and CSA requirements for service, feeder and branch circuit protection
- Class H/K and G fuses with up to 100 kA interrupting rating

* 50% higher IR (300kA) than any other UL and CSA Listed Fuse. Includes Class J, L and R fuses.
** Does not include current limiting circuit breakers or current limiting fuses. Protection determined by comparing published values for let–through for Class CC, J, R, and T fuses versus a symmetrical RMS waveform at 200kA.
*** Test results are based on weighted sales volume of FUSETRON and Ferraz Shawmut (Mersen) fuses by selected amp and volt rating combination. Next leading brand refers to Ferraz Shawmut based on third-party fuse market share data for a twenty-seven month period (July 2008 through September 2010).

Simplify fuse selection by application



	Industrial and commercial applications	LOW-PEAK	FUSETRON	LIMITRON	GENERAL
1	Service, feeder and branch circuit protection	✓	✓	✓	✓
2	Interior lighting	✓	✓	✓	
3	Distribution panels	✓	✓	✓	
4	Disconnect switches	✓	✓	✓	
5	Motor/motor control center	✓	✓		
6	Capacitors	✓	✓		
7	Transformers	✓	✓		
8	Outdoor lighting	✓		✓	
9	Emergency lighting	✓		✓	
10	Electric heat	✓		✓	
11	Welding circuits	✓		✓	
12	Plant lighting	✓		✓	
13	HVAC chillers/blowers	✓			
14	Forklift battery charging station	✓			
15	Emergency generator	✓			
16	Conveyor system	✓			
17	UPS backup power supplies	✓			
18	Switchboards	✓			
19	Elevator control centers	✓			

Easy fuse selection by family

Ultimate protection

LOW-PEAK

CLASS RK1

LPN-RK-SP | LPN-RK | LPS-RK-SP | LPS-RK

CLASS J

LPJ | LPJ

CLASS L

KRP-C

CLASS CC

LP-CC

Advanced protection

FUSETRON

CLASS RK5

FRN-R | FRN-R | FRS-R | FRS-R

Advanced protection

LIMITRON

CLASS RK1

KTN-R | KTN-R | KTS-R | KTS-R

CLASS J

JKS | JKS

CLASS L

KTU | KLU

CLASS T

JJN | JJN | JJS | JJS

CLASS CC

FNQ-R | KTK-R

Basic protection

GENERAL

CLASS H/K

NON | NON | NOS | NOS

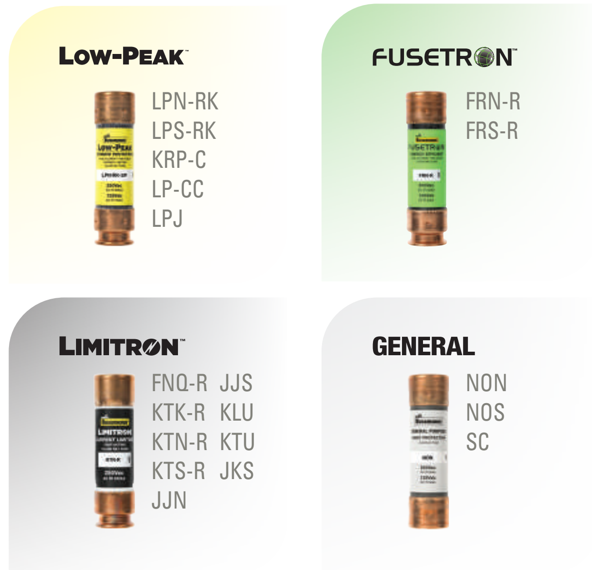
CLASS G

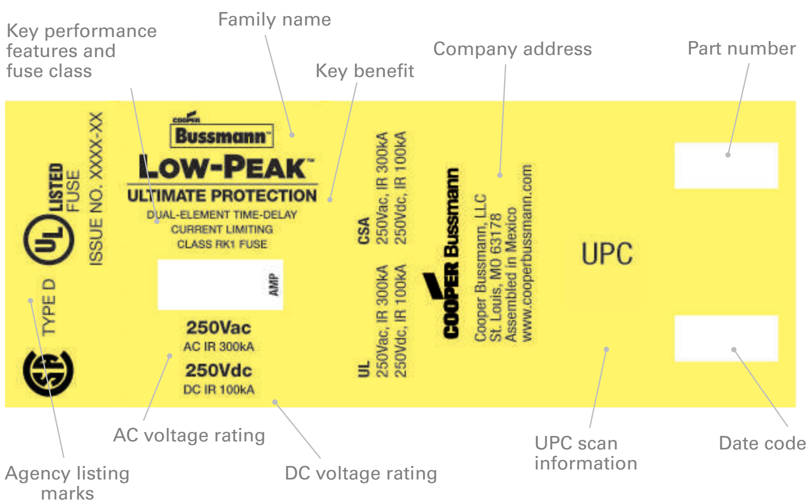
SC | SC

Speed up fuse replacement

Color-coded by family

Each fuse label has a unique identifying color representing the family it belongs to. When it's time to replace a fuse, Bussmann series products makes it easier to search for the replacement. When a "yellow fuse" needs replacing, now you can narrow your search by looking for only the "yellow fuses" in your crib.



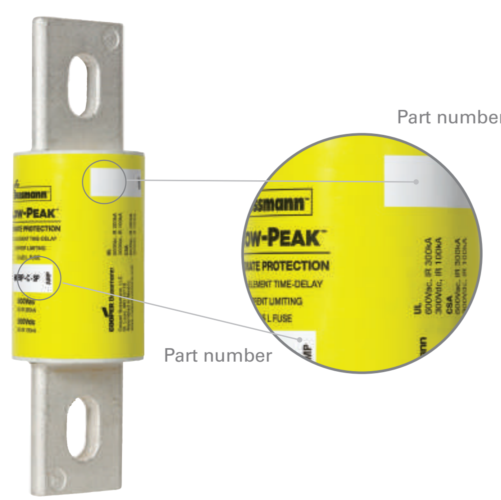


Consistent look for each label

Every fuse label now has a consistent look. Critical fuse information is presented in an easy-to-read format across the entire Bussmann UL low voltage portfolio to help speed replacement.

Easy to find part numbers

To ensure you can easily find the part number when you need to replace fuses, the new label design has the part number located in multiple places of large body size blade fuses. With this updated look, you can easily find the important information regardless of the angle in which the fuse is installed.



Enhance safety and relilability while reducing fuse inventory

Low-Peak Upgrade program

Eaton's Bussmann series Low-Peak Upgrade program leverages our ultimate protection fuses to deliver enhanced safety, improved system reliability and a simplified inventory.

With just three simple steps, it's easier than ever to improve your circuit protection while reducing your fuse inventory and cost. What's more, you'll save time and increase productivity - all by using Low-Peak fuses.

Let our team of experts walk you through the audit, analysis and implementation of a Low-Peak Upgrade and start realizing savings today.

Enhance safety

- Superior current-limitation helps reduce arc flash hazards.
- Interrupting ratings up to 300kA for high fault currents.
- Helps achieve code compliance with OSHA, NFPA® and IEEE®.

Improve system reliability

- Type 2 "no damage" motor starter protection reduces downtime.
- Optional fuse indication to speed troubleshooting.
- Easily meet selective coordination requirements with 2:1 amp ratio with any fuse in the Bussmann series Low-Peak family.

Simplify inventory

- One Bussmann series Low-Peak fuse can replace multiple fuses in a variety of applications.

In just three simple steps, our team of experts will guide you through the Low-Peak Upgrade program:

1. **Audit**
2. **Analyze**
3. **Implement**

Throughout the Bussmann series Low-Peak Upgrade process, you'll have a dedicated team that includes a Bussmann series product authorized distributor and sales representative. Together, they will walk you through the three steps of the program, making it as easy and effortless for you as possible.

Complementary products

The broad portfolio of Bussmann series products include more than just UL low voltage fuses.

Fuse blocks, holders and PDBs

Modular knifeblade fuse blocks

Power distribution blocks

Compact modular fuse holders

Disconnect switches and safety switches

Fused rotary disconnect switches

Quik-Spec™ safety switches

Compact Circuit Protector

Additional fuse portfolio

High speed fuses

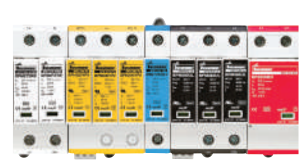
Medium voltage fuses

CUBEFuses™

Surge protection

Data signal surge

Type 1 SurgePOD™
surge protective devices



DIN-Rail surge
protective devices

BUSSMANN SERIES

Low-Peak™ ultimate protection time-delay fuses

Upgrade to 50% more protection

Bussmann series Low-Peak fuses provide ulimate protection for any application.

Product description:

Eaton's Bussmann™ series Low-Peak™ ultimate protection fuses are the industry's only UL® Listed and CSA® Certified fuses with a 300 kA interrupting rating, providing 50% more protection than any other listed fuse*. The high interrupting rating allows for simple, worry-free installation in virtually any application.

Low-Peak fuses are available in Class CC, CF, J, L and RK1, so there is a fuse to meet the vast majority of 600V overcurrent protection needs.

Plus, when upgrading to Low-Peak fuses, existing fuse inventory can be reduced by up to 33%**.

* 50% higher IR (300kA) than any other UL and CSA fuse. Includes Class J, L, and R fuses.

** See Low-Peak Upgrade program for details.

Features and benefits:

Enhanced safety

- Superior current-limitation helps reduce arc flash hazards.
- Interrupting ratings up to 300 kA for virtually any fault current levels.
- Helps achieve code compliance with OSHA®, NFPA® and IEEE®.
- Finger-safe design with the Bussmann series Class CF CUBEFuse™.

Improved system reliability

- Type 2 "No damage"*** motor starter protection reduces downtime.
- Optional fuse indication† to help speed troubleshooting.
- Easily meet selective coordination requirements with 2:1 amp ratio with any Low-Peak fuse.

Simplified inventory

- One Low-Peak fuse can replace multiple fuses in a variety of applications, reducing the need to stock multiple fuses.

*** With properly sized Low-Peak fuses.

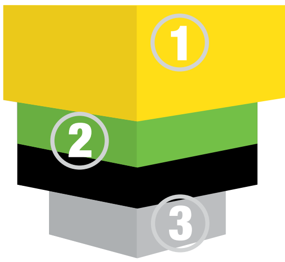
† Available on Class CF, J and RK1 Low-Peak fuses.

EATON

Powering Business Worldwide

Fuses Made Simple™ is the easiest and fastest way to select and specify fuses

Four fuse familes in three tiers of protection offer distinct levels of performance benefits to help speed specification and selection:



Ultimate protection

The best worry-free protection in virtually any application. Low-Peak™ (yellow) fuses 50%* higher interrupting rating than any other similar fuse. Unique dual-element construction delivers a powerful combination of all performance options in one fuse - fast short-circuit protection, current limitation, and time-delay performance with up to 300 kA interrupting ratings.

Advanced protection

Application specific protection for sensitive devices and critical components or motors and transformers.

Limitron™ (black) fuses offer 10X better current limitation than basic circuit breakers or fuses**.

Fusetron™ (green) fuses are 23% more energy efficient*** and the best time-delay performance.

Based on the application, you can choose between fast short-circuit, current limiting performance of Limitron fuses or energy efficient, current limiting, time-delay performance of Fustron fuses and still get a 200 kA interrupting rating.

Basic protection

General purpose (grey) delivers basic single-element fuse protection for service, feeder and branch circuit applications. Featuring up to 50 kA interrupting ratings.

*50% higher IR (300 kA) than any other UL and CSA Class J, L and R fuses.

**Does not include current limiting circuit breakers or current limiting fuses. Protection determined by comparing published let–through values for Class CC, J, R, and T fuses versus a RMS symmetrical waveform at 200 kA.

***Test results are based on weighted sales volume of Fusetron and Ferraz Shawmut (Mersen) fuses by selected amp and volt rating combination. Next leading brand refers to Ferraz Shawmut based on third-party fuse market share data for a twenty-seven month period (July 2008 through September 2010).

Ultimate protection Low-Peak fuses.

TCF Class CF dual-element, time delay fuses

Ratings:

- Volts
  - 600 Vac, 300 Vdc
- Amps
  - 1 to 100A
- IR
  - 300 kA AC
  - 100 kA DC
- Data sheet
  - No. 9000

RoHS

LP-CC Class CC, time-delay fuses

Ratings:

- Volts
  - 600 Vac, 300 Vdc (1/2 to 2-1/2 A, 20 to 30 A)
  - 150Vdc (2-8/10 to 15 A)
- Amps
  - 1/2 to 30A
- IR
  - 200 kA AC
  - 20 kA DC
- Data sheet
  - No. 1023

LPJ Class J dual-element, time-delay fuses

Ratings:

- Volts
  - 600 Vac, 300 Vdc
- Amps
  - 1 to 600 A
- IR
  - 300 kA AC
  - 100 kA DC
- Data sheet
  - No. 1006 (Up to 60 A)
  - No. 1007 (70-600 A

RoHS

KRP-C Class, time-delay fuses

Ratings:

- Volts
  - 600 Vac, 300 Vdc (601 to 2000 A and 3000 A)
- Amps
  - 601 to 6000 A
- IR
  - 300 kA AC
  - 100 kA DC
- Data sheet
  - No. 1008 (601-2000 A)
  - No. 1009 (2001-6000 A)

RoHS

LPN-RK Class RK1 dual-element, time-delay fuses

Ratings:

- Volts
  - 250Vac
    125Vdc (Up to 60 A)
  - 250 Vdc (70-600 A)
- Amps
  - 1/10 to 600A
- IR
  - 300 kA AC
  - 100 kA DC
- Data sheet
  - No. 1003 (Up to 60 A)
  - No. 1004 (70-600 A)

LPS-RK Class RK1 dual-element, time-delay fuses

Ratings:

- Volts
  - 600 Vac
  - 300 Vdc
- Amps
  - 1/10 to 600 A
- IR
  - 300 kA AC
  - 100 kA DC
- Data sheet
  - No. 1001 (Up to 60 A)
  - No. 1002 (70-600 A)

Available with open fuse indication on select amp ratings.

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