Selective Coordination Increases Reliability of Emergency Systems

By Tim Crnko, Manager, Training & Technical Services with Cooper Bussmann

The 2005 and 2008 National Electrical Code® (NEC®) expanded the mandatory requirements for overcurrent protective device selective coordination to include power circuits supplying vital life-safety loads (700.27 emergency systems, 701.18 legally required standby systems, and 517.27 healthcare essential electrical systems) and national security/public safety (708.54 critical operation power systems). Since the adoption of these requirements there has been acceptance by most, resistance by some, and introductions of new products as well as application materials by electrical manufacturers to provide new solutions and approaches for easier compliance.

There are some parallels between the industry acceptance of selective coordination for elevator circuits that became mandatory in the 1993 NEC and the industry acceptance of the expanded selective coordination requirements in the 2005 and 2008 NEC. After the adoption of 620.62 requiring selective coordination for elevator circuits, a few in the industry fought for the ouster or dilution of that requirement for the next three or more Code cycles. Over time, engineers, installers, and enforcers adapted to these requirements, and proposals to eliminate or dilute 620.62 were minimal during recent Code cycles. Through the 2011 NEC Proposal Stage, selective coordination remains as a mandatory requirement for the sections added in the 2005 and 2008 NEC.

Understanding the action of the Code Panels in requiring selective coordination and resulting improvements in the industry in adapting to these requirements illustrates the progress made to comply.

First, it is important to emphasize that selective coordination is only mandatory for a few power circuits supplying vital loads that are intended for life safety. These requirements are not for all facilities or circuits. These vital loads are powered by electrical circuits that have special NEC requirements to ensure attainment of at least minimum requirements for high reliability power. These requirements are in addition to the general requirements of NEC Chapters 1 to 4, and are located in NEC Chapters 5, 6, and 8.

For instance, the loads on these circuits are critical during emergency egress of high rise buildings and sports arenas. Personnel safety during emergencies is dependent on maintaining power to these vital loads. Emergency lighting, as an example, must be maintained for building egress.

Typical high rise building emergency egress design utilizes emergency lighting and pressurized stairways. Reliability of power for fire alarm systems and notification systems are critical. NFPA 72 is evolving by including mass notification systems.

In the CSE July 2009 article *Ensuring Emergency Power Performance,* "Many items, while seemingly unimportant, can jeopardize the operation of the emergency power supply system (EPSS). Consider convenience receptacles or light fixtures at a low elevation after a flood. They may be served by overcurrent devices with poor selective coordination that can trip circuit breakers farther up in the system. As a result, portions of the system far removed from the receptacles or lights can be disabled."

Unfortunately, all too often, the design and installation meet only the minimum requirements of the NEC. Personalize it by asking which loads you would want to be without if your family and you were on top of a high rise and must evacuate during a catastrophe. The principle of selective coordination is to minimize the loss of power to only those loads that must be removed if there is an electrical fault. If there are fires or building structure failures occurring, you do not want to unnecessarily lose life safety loads due to a lack of selectively coordinated overcurrent protective devices. Without these NEC selective coordination requirements, during times of building system duress such as fires, floods, hurricanes, man-caused attacks, etc, cascading overcurrent protective devices would be permitted and life-safety loads could unnecessarily lose power.

Most in the industry have adjusted to the 2005 and 2008 NEC selective coordination requirements. This is in part due to the contributions by overcurrent protective device manufacturers who have published application material to assist in the design and installation of selective coordination compliant systems.

Providing a selectively coordinated fuse system is relatively simple by following a fuse manufacturer's selectivity amp rating ratio guide. In most cases, selective coordination between fuses does not require a short-circuit current study or plotting the time-current curves; just follow the amp rating ratios. Also, when using the most current-limiting type fuses, normally the arc-flash hazard analysis results are acceptable and equipment protection is achieved. In some larger ampacity circuits, if there are cases where the arc flash hazard is higher than desired, other means may be deployed such as optic sensing technology with overcurrent relays that can signal a switch to shunt trip and thereby reduce the arc flash hazard. An example of product innovation to satisfy the selective coordination requirements is the new fusible branch panelboard for lighting and other panelboard loads.

Figure 1 Fusible branch circuit panelboards have recently been introduced, having the same width and depth as typical molded case circuit breaker panelboards. Courtesy of Cooper Bussmann.

The circuit breaker (CB) manufacturers now provide tables of circuit breakers that have been tested to achieve selective coordination. In addition, they explain ways to comply by using circuit breakers with (1) short-time delay settings, (2) fixed high instantaneous trip settings, or (3) zone selective interlocking communications and tripping restraint. Short-time delay settings are sometimes beneficial in the achievement of selective coordination, but may also be associated with an increase of the arc flash hazard levels. Because of this, the circuit breaker manufacturers provide options such as zone selective interlocking of CBs or maintenance switches. With a maintenance switching option on a CB with short-time delay, when maintenance is being performed, the CB can be switched to an instantaneous trip setting. CB short time delay settings also may negate equipment protection. However, the industry has responded with 30-cycle withstand ratings for automatic transfer switches and motor control centers.

Selectively coordinating a system with ground fault relays and phase overcurrent devices sometimes provides a challenge for the inexperienced design engineer. Inverse time ground fault relays often provide the right amount of delay in order to achieve selective coordination with the phase overcurrent protective devices. Another design option is to eliminate the need for ground fault relays by utilizing high resistance grounded systems to supply all the non neutral loads. High resistance grounded systems do not require ground fault protection relays and can increase system reliability. The loads requiring neutrals can then be supplied from a feeder of the high resistance grounded system through a transformer with a solidly grounded secondary. If the secondary rated current is kept to 800A or less, no GFP relay is required.

All of the objections to mandatory selective coordination were vetted by the 2005 and 2008 NEC Proposal and Comment process, and Code Panels 13 and 20 retained selective coordination as a mandatory requirement.

Even still, some are advocating that selective coordination should be mandatory for times only greater than 0.1 seconds (6 cycles). Such a change would permit systems to be designed and installed where overcurrent protective devices would be coordinated for only overload conditions. Selective coordination for times only greater than 0.1 seconds would ignore the instantaneous trip of circuit breakers and the current-limiting range of fuses. Proposing selective coordination for times only greater than 0.1 seconds is an attempt to gut the requirement. See the insert.

The NEC Code Panels were clear in their definitions, requirements, and panel statements that selective coordination performance is for the full range of overcurrents (overloads and faults) at the point of application, irrespective of how fast the overcurrent protective devices open. In considering the proposals and comments in the 2005 and 2008 NEC process, the Code Panels considered proposals and comments for times greater than 0.1 seconds. To understand the requirements of the NEC, it is necessary to also study the panel statements. In the 2008 NEC process, Proposal 13-146 proposed a Fine Print Note to 700.27 essentially stating that selective coordination was applicable for times only greater than 0.1 seconds. Code Panel 13 rejected this proposal with the following statement: "*The instantaneous portion of the time-current curve is no less important than the long time portion.*"

Summary:
Selective coordination is necessary for the continued operation of critical loads under emergency situations. CMP 13 very appropriately addressed the issue with their statement *"Selective coordination increases the reliability of the emergency system."* Challenges to requirements for selective coordination in emergency systems, legally required standby systems, and critical operations power systems have been addressed by the CMPs in the 2005, 2008 NEC cycles and in the 2011 ROP stage and are expected to continue in the ROC stage for the 2011 cycle. These challenges are expected to decrease over time as design engineers develop a deeper understanding of the design techniques and as manufacturers introduce new products and solutions to meet designers' needs.

Why Selective Coordination for Only Times Greater than 0.1 Second is Flawed

With a selective coordination requirement for only times greater than 0.1 second and a system designed to the minimum, low level to high level faults would be permitted to cascade (trip or open) multiple levels of overcurrent protective devices (branch, feeder, and main). The result would permit emergency loads being unnecessarily interrupted due to a lack of selective coordination even though compliant with a requirement for times only greater than 0.1 second.

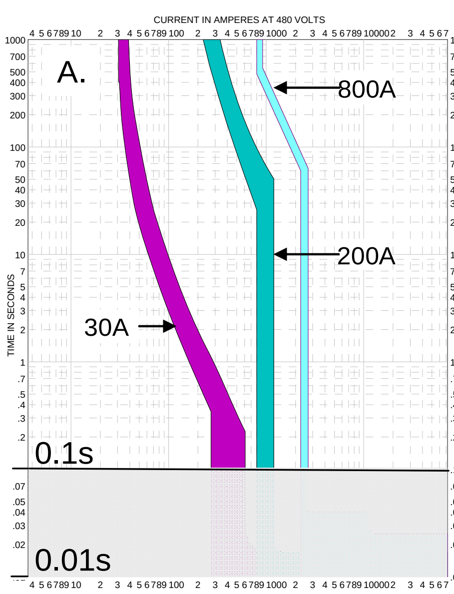
To illustrate this, Graphs A and B depict the time-current curves of the same 30A, 200A, and 800A system.

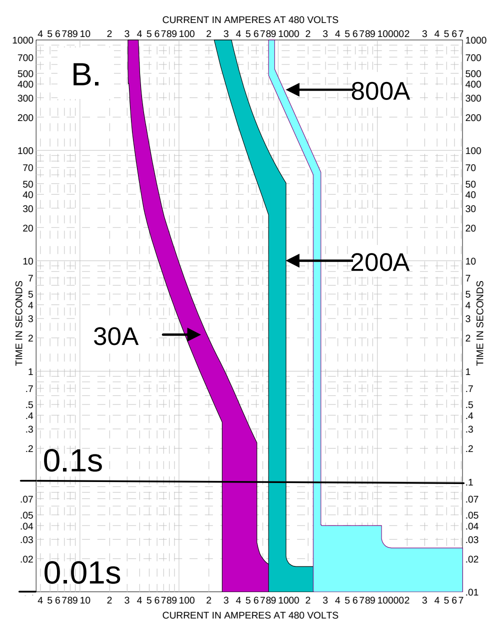
Graph A shows no crossover or intersection of the circuit breaker curves above 0.1 second. If the requirement for selective coordination were for times only greater than 0.1 seconds, Graph A would be used as evidence to show these circuit breakers would comply.

Graph B depicts the circuit breaker curves with the analysis for the full range of overcurrents as required by the present NEC 700.27 text. Graph B shows the crossover of the circuit breakers in their instantaneous trip region. Graph B shows a lack of coordination between the 30A and 200A circuit breakers for ground, arcing, and any combination of phase faults as low as 800A or greater. Any type of fault as low as 2200A or greater on the 30A circuit can trip the 800A circuit breaker as well. If the fault is on the 200A feeder circuit, any type fault current of 2200A or greater can trip the 800A circuit breaker, as well. These are low available fault currents easily achieved in almost every essential electrical system via a line-ground fault, line-line fault or three phase fault, arcing or bolted.

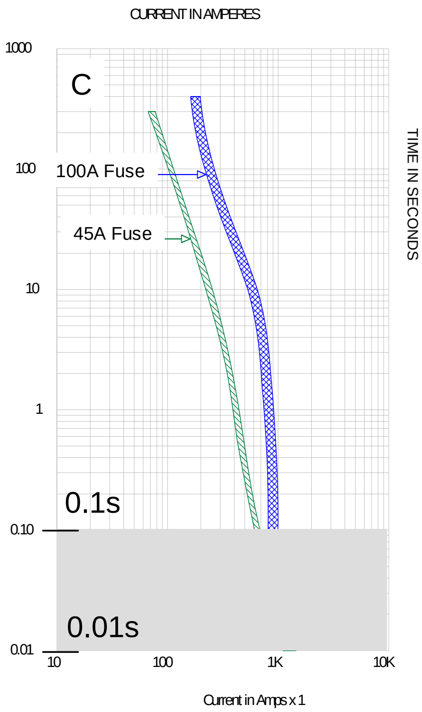
The same situation can occur if fuses are not chosen and installed properly. Graph C shows fuse time-current characteristics where the curves are evaluated for times only greater than 0.1 second. Graph D shows the same fuse curves, but below 0.1 seconds; obviously there is a lack of coordination for fault currents greater than where the fuses cross.

Unless, the selective coordination analysis is for the full range of available overcurrents and the installer uses the proper settings, it is expected that low to high level faults will be permitted to cascade multiple levels of overcurrent protective devices. The 2008 NEC requires selective coordination for the full range of overcurrents available irrespective of the opening time of the protective devices.

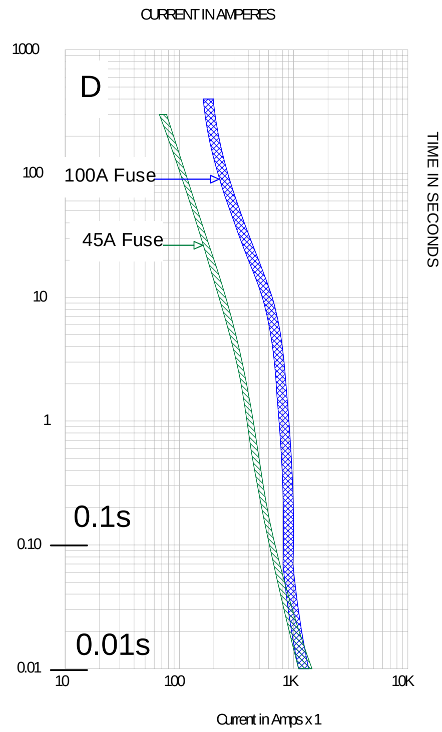




Graph A *Graph B*



Graph C



Graph D

About the Author:
Tim Crnko is Manager, Training & Technical Services with Cooper Bussmann. He has been associated with Cooper Bussmann for 23 years with most of his focus on the application of overcurrent protective devices. He has authored several articles and papers and presented at numerous technical seminars related to overcurrent protection and electrical safety. He received his B.S.E.E. and M.S.E.E from the University of Missouri at Columbia. He is a member of IEEE, NEMA, NFPA and IAEI. He is a committee member of the NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*.