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Are the New 2005 NEC Selective Coordination Requirements Causing an Increase in Arc Flash Energies and Reducing Distribution System Reliability?

The 2005 NEC has new sections that require people transporting equipment such as elevators and escalators, Emergency, Standby, and Essential Systems to be selectively coordinated. This requirement has radically affected the way engineers and electricians design these systems. Today's systems use fuses and circuit breakers to provide protection to the cables, transformers, panelboards, switchboards, and other equipment. Fuses are relatively easy to selectively coordinate in the system. However, elevator coordination panels, fused lighting and distribution panels are not always desired by the owner. This is due to their physical size and thirty ampere maximum branch size for panelboards. Fuses can also cause single phasing issues and the need to wear Arc Resistant PPE to replace a fuse.

Most circuit breakers have an instantaneous trip unit or trip function that makes selective coordination difficult to achieve. To achieve this selective coordination, the circuit breaker trip units must have instantaneous trip function removed, defeated, or set above the available fault current. When the instantaneous trip function is removed, the breaker trip time is increased and this will increase the arc flash energy and electrical hazard.

It is very expensive to eliminate the breaker instantaneous settings for many locations. In many places, large framed breakers with high instantaneous overrides must be. These larger and more expensive framed breakers are forcing the design engineers to design systems that use <u>*less*</u> protective devices. They are *eliminating* panelboard main breakers and using fed through lugs on power risers.

With this design, a fault in a panelboard will instead trip out the riser feeder breaker in the main switchboard. For panelboard maintenance or new circuit/circuit breaker installation, it requires electricians to de-energize the entire feeder or work in the Panelboard while energized. This new design actually makes the distribution system less reliable and more electrically hazardous than previous designs.

There are various NEC sections referenced below that require selective coordination:

Article 100 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.*

Section 620-51(a) Coordination *The fuses or circuit breakers provided for in the disconnecting means shall be selectively coordinated with any and all other supply side overcurrent-protective devices.*

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

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

Properly sized upstream and downstream fuses can be selectively coordinated for all levels of fault current. Usually, it is impossible to have selective coordination between devices that have instantaneous characteristics (i.e. circuit breakers and relays).

1) **All molded case circuit breakers (MCCB) and insulated case circuit breakers (ICCB) must have an instantaneous setting.**
   a) The instantaneous can be adjustable (usually 5 to 10 times the trip rating)
   b) The instantaneous can be fixed and equal to trip before the breaker short time rating is exceeded. (usually between 10,000 to 40,000 amperes)
   c) MCCB and ICCB are less expensive and are more compact than the larger power circuit breakers. More compact means smaller switchboards and electrical rooms.

2) **Only Power Circuit Breakers (PCB, metal framed breakers… i.e. GE Type AKR) can have a solid state trip unit without an instantaneous setting.**
   a) These are very expensive.
   b) These require switchgear class equipment versus cheaper switchboard class.
   c) PCB and switchgear are physically bigger. (Bigger electrical rooms and elevator rooms are needed.)
   d) A PCB installed in switchboards must have an instantaneous setting (fixed or adjustable).

3) **Not all fuses can coordinate with each other.**

a) There must be at least a 2:1 size difference between the upstream and downstream fuse.
b) This ratio varies from manufacture and type of fuse.
c) If the ratio is not correct, fuses will not coordinate in the instantaneous region.

4) **Circuit breakers with instantaneous settings and fuses usually do not coordinate in the instantaneous region.**

5) **When breakers have an instantaneous setting….**
   a) They are not selectively coordinated in the area of overlap.
   b) They can only be coordinated if the level of fault current between the upstream and downstream breakers is great enough to prevent overlapping.
   c) They usually can be selectively coordinated in the long time, short time, and some part of the instantaneous region.

6) **The fixed instantaneous override setting for MCCBs and ICCBs vary from breaker type and manufacturer.**
   a) GE MCCB Spectra breakers with MVT Plus trip units do not have a fixed instantaneous override option.
   b) Square D's molded case circuit breaker fixed instantaneous settings vary from 10,000 amperes to 40,000 amperes.
   c) Siemens varies as well.

7) **Is this a real problem or a perceived problem? Looking at the device time current curves will show overlapping in the instantaneous region.** However, our experience performing over 1,800 power system studies have shown that devices not tripping in sequence is extremely rare. When it does happen, usually a protective device study was not performed or the breakers were not set to the recommended settings listed in the study. The manufacturers ship the breakers and relays with the settings at minimum. When devices are set to minimum, they tend to over lap in the long, short, and instantaneous regions.

8) **Most faults are lower Line-to-Ground.** Most faults are not the three phase bolted faults producing the maximum available fault current. Many studies and experience has shown that the faults are line-to-ground faults which result in much lower fault currents. When fault currents are lower in magnitude, the phase protective devices will trip in the short time or long time delay region, not in the instantaneous region. They tend to trip in sequence in these regions. However, if the main breaker has ground fault protection and

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the feeder breakers do not, the main may trip first. This is because the NEC limits the maximum ground fault trip functions and relays pickup to 1,200 amperes and 0.5 second delay. In many cases, this makes the main breaker much more sensitive to line-to-ground faults than the feeder breakers.

9) **Our experience has shown…..**
   a) It is extremely difficult to obtain total selective coordination in the instantaneous region for all levels of fault current.
   b) That if the fault current is above 35,000 amperes, most common MCCB and ICCB with fixed instantaneous override, can not be used… the instantaneous regions will overlap.
   c) Fuses are not the answer because:
      i) They have a problem with coordination between them and circuit breakers
      ii) There must be a ratio (typically 2:1) between upstream and downstream fuse sizes.
      iii) They have a single phasing problem… only one phase blowing.
      iv) When a fuse blows and it must be replaced, the maintenance personnel are exposed to the energized line side of the switch. They must wear the appropriate PPE to protect themselves from Arc Flash hazards.

10) **It is our opinion that the NEC code has required something that is extremely difficult and expensive to obtain. It their attempt to increase system reliability, they are actually systems less reliable and more hazardous.**

A COMPROMISE IS NEEDED!!!!!

About the Author

Bob Fuhr graduated with a B.S.E.E. from the University of Wisconsin in 1980. Before graduating, Mr. Fuhr worked for Madison Gas and Electric in Madison, WI and Tennessee Valley Authority in Knoxville, TN.

After graduation, he worked for General Electric Company from 1980 to 1986 as a Field Engineer performing commissioning and start up tests on a multitude of power distribution equipment.

From 1986 to 1989 he worked as a Senior Facilities Engineer at the University of Washington. There he re-commissioned the electrical power distribution system for University Hospital.

In 1986, he established Power Systems Engineering, a consulting firm that specializes in power systems studies, power quality services, and commissioning services. He also teaches classes in electrical safety, short circuit calculation, protective device coordination, arc flash hazard assessment, power factor correction, harmonics, and filter design.

Mr. Fuhr is a Professional Engineer registered in Alaska, Arizona, California, Colorado, Nevada, Oregon, and Washington.

Bob has been involved in IEEE and the Industrial Applications Society since 1986. He has served as an officer for IAS from 1988 to 1992. He was the 1991-92 Chairperson of IAS. He was a Member-at-large for the Seattle Section of IEEE for 1992-93. He is an IEEE Senior Member. He is also member of the Electric League of the Pacific Northwest.