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Selective Coordination—To What Level?

Introduction

Requirements for selective coordination were added to Article 620 in the 1993 National Electrical Code® (NEC®), Articles 700 and 701 in the 2005 NEC, Article 708 in the 2008 NEC, Article 695 in the 2011 NEC, and Article 645 in the 2014 NEC, there has been a question regarding what level of selective coordination is required by the Code. The fact that some jurisdictions require coordination to 0.1 seconds, and many Overcurrent Protective Device (OCPD) time-current curves (TCCs) only go down to 0.01 seconds, contribute to the confusion. Action by the National Fire Protection Association® (NFPA®) and a change to the definition in the 2014 NEC has helped answer this question.

NEC Selective Coordination Installation Requirements

Article 700 covering Emergency Power Systems, Article 701 covering Legally Required Power Systems and Article 708 covering Critical Operations Power Systems all include a similarly worded selective coordination installation requirement. For example, the text in Article 700 reads as follows:

> **700.28 Coordination**. Emergency system(s) overcurrent devices shall be selectively coordinated with all supply side overcurrent protective devices.

The only difference in the wording of Sections 701.27 and 708.54 involves the name of the system.

The key issue is that none of these sections directly addresses the performance of these systems.

NFPA Guidance

The NFPA has recognized that various codes and standards address coordination, which can create conflict, therefore, it was prudent for the NFPA to establish jurisdictional guidance for each technical committee. The NFPA has directed that the technical committees responsible for documents that address system performance write performance requirements and that the technical committees responsible for documents that address installation write installation requirements based on the following definitions:

> **Performance Requirement.** A specification of the manner in which equipment or a system is intended to function or operate.
>
> **Installation Requirement.** A specification of the material and process associated with putting equipment in place and making it ready for use in accordance with performance requirements.

NFPA 99 Performance Requirements

The 2012 edition of the NFPA 99 Health Care Facilities Code defines an essential electrical system as (emphasis added):

> A system comprised of alternate sources of power and all connected distribution systems and ancillary equipment, designed to ensure continuity of electrical power to designated areas and functions of a health care facility during disruption of normal power sources, and also to minimize disruption within the internal wiring system.

The following performance requirement for Types 1, 2 and 3 essential electrical systems is stated in clauses 6.4.2.1.2, 6.5.2.1.1 and 6.6.2.1.1:

> Overcurrent protective devices serving the essential electrical system shall selectively coordinate for the period of time that a fault's duration extends beyond 0.1 second.

Annex A goes on to explain in clauses A.6.4.2.1.2, A.6.5.2.1.1 and A.6.6.2.1.1that:

> It is important that the various overcurrent devices be coordinated, as far as practicable, to isolate faulted circuits and to protect against cascading operation on short-circuit faults. In many systems, however, full coordination could compromise safety and system reliability. Primary consideration also should be given to prevent overloading of equipment by limiting the possibilities of large current inrushes due to instantaneous reestablishment of connections to heavy loads.

2014 NEC Changes to Article 517

Section 700.28 impacts health care facilities, in that Section 517.26 now states:

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

Article 517 has amended the requirements of Article 700 by adding the following text to correlate with NFPA 99:

> **517.30 Essential Electrical System for Hospitals.**
>
> **(G) Coordination.** Overcurrent protective devices serving the essential electrical system shall be coordinated for the period of time that a fault's duration extends beyond 0.1 second.
>
> Exception No. 1: Between transformer primary and secondary overcurrent protective devices, where only one overcurrent protective device or set of overcurrent protective devices exists on the transformer secondary.
>
> Exception No. 2: Between overcurrent protective devices of the same size (ampere rating) in series.
>
> Informational Note: The terms coordination and coordinated as used in this section do not cover the full range of overcurrent conditions.

NFPA 110 Performance Requirements

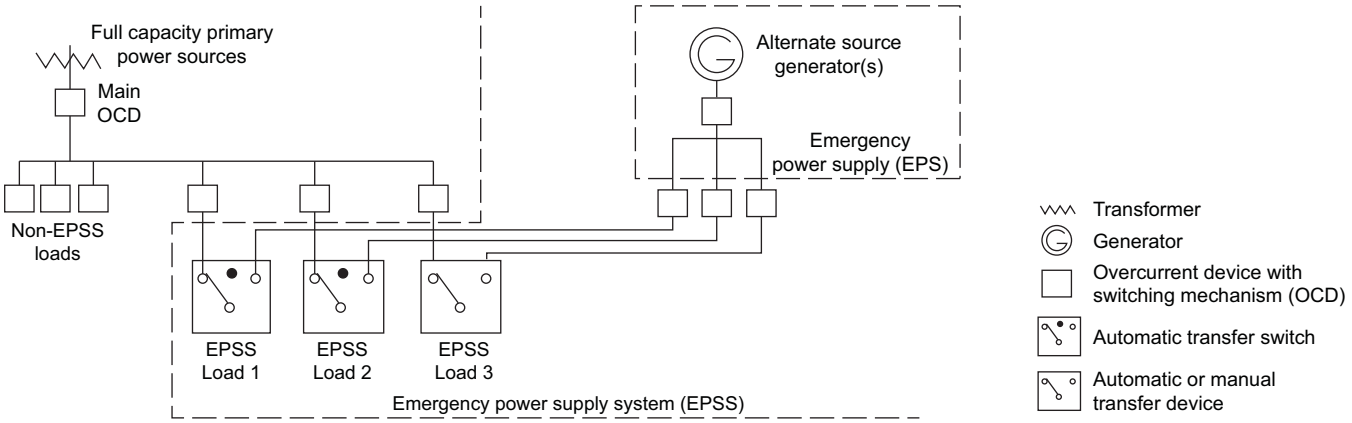
NFPA 110 is the Standard for Emergency and Standby Power Systems. Before discussing the NFPA 110 requirements, let's start by understanding the scope of the standard (emphasis added):

> **1.1 Scope**. This standard covers performance requirements for emergency and standby power systems providing an alternate source of electrical power to loads in buildings and facilities in the event that the primary power source fails.

The 2012 edition of the NFPA 110 defines an emergency power supply system (EPS) as (emphasis added):

> A complete functioning EPS system coupled to a system of conductors, disconnecting means and overcurrent protective devices, transfer switches, and all control, supervisory, and support devices up to and including the load terminals of the transfer equipment needed for the system to operate as a safe and reliable source of electric power.

This definition is clarified by the drawing in Appendix B.1(a):



The standard requires the following:

> **6.5 Protection.**
>
> **6.5.1 General.** The overcurrent protective devices in the EPSS shall be coordinated to optimize selective tripping of the circuit overcurrent protective devices when a short circuit occurs.
>
> **6.5.2 Short Circuit Current.** The maximum available short circuit current from both the utility source and the emergency energy source shall be evaluated for the ability to satisfy this coordination capability.

Annex A goes on to explain in clause A.6.5.1 that:

> It is important that the various overcurrent devices be coordinated, as far as practicable, to isolate faulted circuits and to protect against cascading operation on short circuit faults. In many systems, however, full coordination is not practicable without using equipment that could be prohibitively costly or undesirable for other reasons. Primary consideration also should be given to prevent overloading of equipment by limiting the possibilities of large current inrushes due to instantaneous reestablishment of connections to heavy loads.

2014 NEC Definition Change

A change has been made to the definition of selective coordination in Article 100 that impacts what the NEC means when it uses this term.

> **Coordination (Selective).** Localization of an overcurrent condition to restrict outages to the circuit or equipment affected, accomplished by the selection and installation of overcurrent protective devices and their ratings or settings for the full range of available overcurrents, from overload to the maximum available fault current, and for the full range of overcurrent protective device opening times associated with those overcurrents.

Obviously this revised definition will necessitate a change in the use of the term “selective coordination” in NFPA 99. It will also limit the ability to use the requirements in NFPA 110 to design systems requiring emergency and standby power in those jurisdictions that have adopted the 2014 NEC.

Specifying the Level of Selective Coordination

In jurisdictions or applications where NFPA 99 applies, coordination of the essential electrical system should be required to 0.1s. This means that the TCCs of OCPDs that are in series with one another in an essential electrical system should not overlap or cross one another for fault currents that would cause the upstream device(s) to operate in greater than 0.1s.

In jurisdictions that have yet to apply the 2014 edition of the NEC, coordination of the emergency, legally required, critical operation and certain fire pump power supply systems should be at least optimized as far as practicable.

In such applications, selective coordination back to the alternate source is what is required by NFPA 99 and 110 and editions of the NEC prior to 2014.

This is not to say that these are the best coordination performance levels that can or should be achieved and that coordination up to the utility should be ignored. These are minimum performance requirements, as is the case with any code or standard. There is nothing that prevents or discourages achieving a higher level of performance. Achieving higher performance is a matter of an engineer designing the entire system for appropriate performance.

Coordination Specification — Time vs. “Total”

Some engineers have specified coordination down to 0.01s, probably because many OCPD TCCs are cut off below that time, but doing so does not guarantee total coordination.

Current limiting OCPDs have the ability to totally clear faults that are in their current limiting range in one half cycle or less, which on a 60 Hz system is less than 0.01s. Trying to use TCCs that are cut off at 0.01s to evaluate coordination if a high fault current event were to occur would be impossible because the operation of the devices would be “off the graph”. (Note: Current limiting circuit breaker TCCs may be published down to 0.001s.) Ratio tables need to be used to evaluate current limiting fuse coordination below 0.01s.

But even standard molded case circuit breakers begin operating in far less than 0.01s, sometimes in less than 0.001s. The moment the contacts part on the downstream circuit breaker, the dynamic impedance of the resulting arc will limit the level of let-through current that will flow through the upstream device. As TCCs tell nothing about let-through current, in order to evaluate the total coordination of two circuit breakers when the prospective fault current exceeds the minimum instantaneous trip point of the upstream circuit breaker, coordination tables must be employed. (Note: This is the same principle as fuse ratio tables.)

Engineers who want their systems to be totally, completely and fully coordinated should specify “selective coordination”. If coordination to a lesser level, such as 0.1s, is desired, they should specify the level they want using the word “coordination”.

Summary

In health care facilities, NFPA 99-2012 requires that the essential electrical system be coordinated to 0.1s for all types of fault current generated by the alternate source.

In power systems requiring emergency or standby power where the 2014 NEC has yet to be adopted, NFPA 110-2010 requires that the OCPDs feeding the automatic transfer switch(s) be selectively coordinated to the extent practicable.

In Articles 620, 645, 695, 700, 701 and 708 systems where selective coordination is required and the 2014 NEC has been adopted, selective (total) coordination will be required.

Specifying selective coordination with a time value such as 0.01s is not the same as total coordination. If total coordination is what is desired, then “selective coordination” should be specified. Circuit breaker coordination tables and fuse ratio tables may need to be employed to determine selective coordination depending on where the level of fault current is with respect to the operating characteristics of the upstream OCPD.

For More Information

Guidance on Coordinating Requirements with Other NFPA Technical Committees, NFPA Standards Council Meeting Final Minutes, October 19-20, 2010, attachment 10-10-23

NEC Selective Coordination–Up to Which Source?, Schneider Electric data bulletin 0600DB0902

Guide to Power System Selective Coordination, Schneider Electric data bulletin 0100DB0603

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