

Information Sheet # 31

Selective Coordination of Circuit Breakers

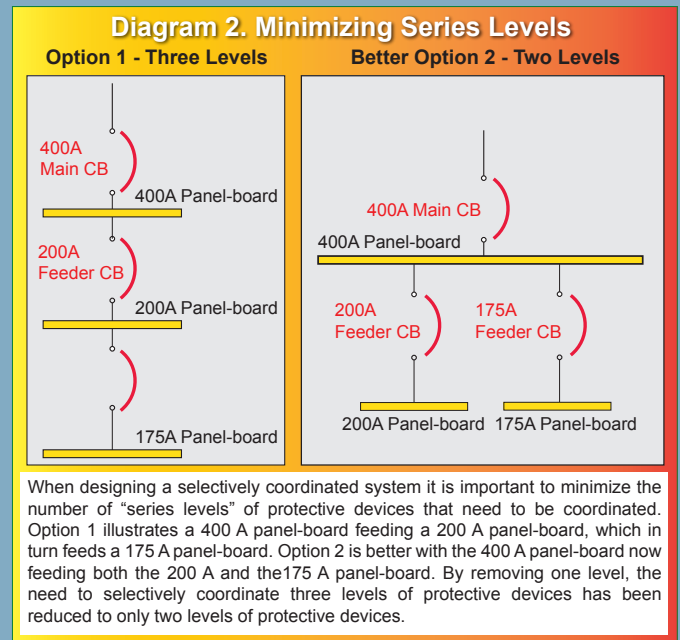
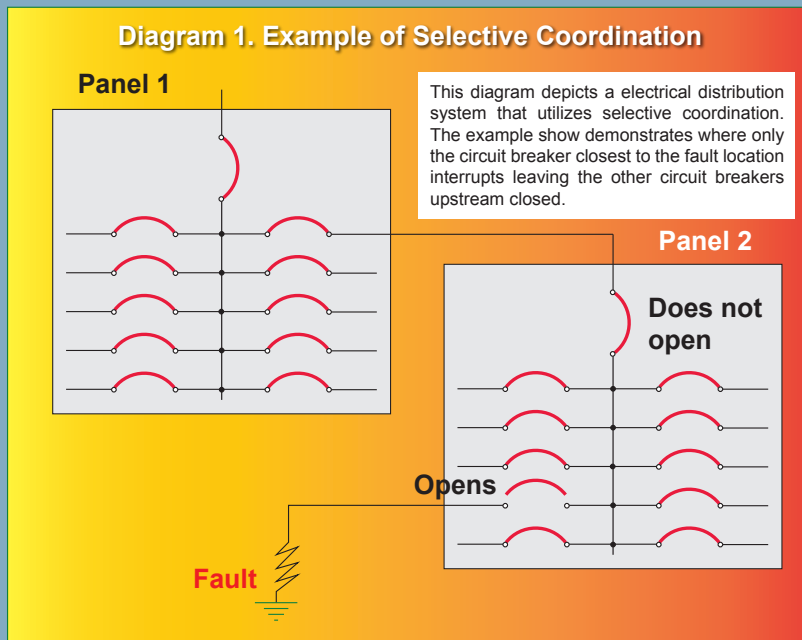
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1.0 Introduction

Selective Coordination (SC) of Circuit Breakers is needed to comply with National Electrical Code and the requirements and the standards of National Fire Protection Association (NFPA) 110 and NFPA 99 - Health Care Facilities Code. The principal objective of Selective Coordination is to isolate the faulted circuit within an electrical system while maintaining power to the other, normally functioning parts of the system.

This Information Sheet addresses the principal concerns limited to selective coordination of overcurrent. (Continued over)

Examples of Selective Coordination



INSTANTANEOUS TRIP REQUIREMENTS OF SWITCHGEAR AND SWITCHBOARDS

Equipment Type	Instantaneous (3 Cycle) Clearing		
	MAIN	FEEDER	Comments
Switchboard (Tested to UL 891)	On or Off	On	1
Switchgear (Tested to UL 1558)	On or Off	On or Off	2
Comment 1	Disabling the instantaneous off function of a switchboard's main power circuit breaker is acceptable, as long as the feeder breakers still have an instantaneous off function to clear a through-fault downstream of the switchboard within 3 cycles. The impact to ATS's (or other intermediate switching devices that are not overcurrent devices) which aren't typically rated for fault bracing greater than 3 cycles (and 18 cycle can be an option) should be considered.		
Comment 1	Disabling the instantaneous off function of a switchgear main or feeder power circuit breaker is acceptable, as long as the available fault current does not exceed the 30-cycle short-time rating of the circuit breaker or switchgear. The impact to ATS's (or other intermediate switching devices that are not overcurrent devices) which aren't typically rated for fault bracing greater than 3 cycles (and 30 cycle can be an option) should be considered.		

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2.0 Definitions:

The NEC definitions for selective coordination and overcurrent are:

- **Selective Coordination.** 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
- **Overcurrent.** Any current in excess of the rated current of equipment or the ampacity of a conductor

3.0 Design: (see diagram 2)

Whenever design of selective coordination is considered, it should never be done without also considering the impact to arc flash and to fault bracing. All three of these electrical studies have nearly complete overlap of components. A design of any one aspect by itself is likely to be neglectful. It is best if all three are taken together as a system. What benefits arc flash is often a detractor to coordination, and vice versa. Fault bracing may be benefited by or be hindered by the decisions of either arc flash or selective coordination.

Compromises in code compliance or other project criteria can be avoided by requiring approved coordination studies before product orders are placed. Any system performance reductions that are required can be part of an informed design decision rather than unfortunate afterthoughts.

Assessing the impact of maintenance requirements in addition to system function will result in changes in what previously were considered industry-standard design practices. For example, traditional design would require turning off power to a building in order to service fire pump equipment connected to a utility transformer if the pump equipment had a non-approach arc flash label. But if service requirements are considered during the design process, new solutions can be developed.

Certain codes may be at one point in the design process be voluntary, but once they are adopted, other added requirements and costs are not.

4.0 Availability:

Individual manufacturers may have distinctive and even unique solutions in their product offerings.

- Not all time-current curve adjustment options are created equal. Some offer more dynamic range in time-current curve shaping
- Some manufacturers have options in zone selective interlock that others don't. Some may need to use much more expensive (or larger) equipment to be equal
- Some manufacturers may offer means of integrating power generation system functionality into distribution system functions, such as relays or programmable logic controllers (PLCs). Others might not
- Some generator manufacturers are proposing their arrays of smaller gensets to be equal to and more economical than a fewer larger gensets, but not addressing potential deficiencies in selective coordination. How to help such generation systems to offer full selective coordination may or may not be thought through

5.0 Initial Study:

Designing a coordinated electrical distribution system requires knowledge about the application of the system and the circuit breakers being specified so that only the smallest portion of the overall system is de-energized by an abnormal condition. This is done by careful selection and setting of the protective devices throughout the system.

This work is best done early in the design phase when it is easier and more effective. The only true method to achieve selective coordination and equipment protection is to conduct a comprehensive short-circuit study together with an overcurrent coordination study and arc flash study.

6.0 Performance:

When power availability is critical, maximum electrical service continuity

is achieved by placing mission-critical circuit breakers where they will clear the fault immediately upstream of the occurrence. This is very important in emergency power distribution systems such as data centers, hospitals and other applications where continuity of service is not merely desirable but also vital.

Today's technology optimizes current, time and energy selectivity and allows breakers to clear any fault immediately upstream and permits the remaining areas of the electrical system to continue operating without any interruption. This has been achieved by rigorous test procedures to certify the objectives. (See diagram 1)

7.0 Codes:

The latest code requires selective coordination for:

- Damage Curves [NEC 110.10] conductors, transformers and other electrical equipment have limits as to the amount of short circuit they can sustain. Protective devices must coordinate to prevent damage. Applies to normal and emergency systems
- Emergency Systems [NEC 700.27] (e.g. wherever backup power is required within 10 seconds 700.12)
- Legally Required Standby Systems [NEC 701.27] (e.g. wherever backup power is required within 60 seconds 701.12)
- Critical Operations Systems [NEC 708.54]
- All elevators NEC 620.62 (whether normal or emergency)
- All distribution up to every ATS for all EPSS systems governed by NFPA 110 [NFPA 110: 6.5.1].
- Selective coordination is required where necessary for orderly shutdown of equipment to minimize hazards [NEC 240.12].
- Selective coordination is required for fire pumps part of a campus wide distribution system [NEC 695.3(C)(3)].
- Selective coordination is required for all series rated equipment [NEC 240.86]
- Selective coordination is for multi-tiered GFI trips [NFPA 99: 4.3.2.2.4.1, 4.3.2.5.2 and NEC: 203.95, 517.17(C), 708.52(D)]

OCPD (Over-current Protective Device) coordination should also be targeted for all other distribution systems generally, where cost impact is nominal, as it adds functionality to the owner's operations. Note that NFPA 110 does require coordination up to the ATS for all EPSS systems but only NEC 700 and NEC 701 reference NFPA 110, not NEC 702 (Optional Standby).

Taking the above code requirements and applying them to a Healthcare facility, the selective coordination is required for:

- The entire Life Safety and Critical Branch [per NEC 700.27]
- The entire Equipment Branch [per NEC 701]
- All elevators [per NEC 620.60]
- All ground fault [NFPA 99: 4.3.2.2.4.1, 4.3.2.5.2 and NEC: 203.95, 517.17(C), 708.52(D)]
- Industry practice is to tend to avoid series rated equipment, but where you have it, it will need to be coordinated also [NEC 240.86]

The above list doesn't include the new NEC 2014 240.87 requirements for special features to be included with any breaker device of a 1200 amp frame or larger, with compliance path options such as:

- Zone-selective interlocking
- Differential relaying
- Energy-reducing maintenance switching with local status indicator
- Energy-reducing active arc flash mitigation system

Note that this requirement, once required, will impact the of one or both of the 'arc flash' and 'selective coordination' assessments.

8.0 Further Reading:

In a recent May 2013 meeting on NFPA 99 Health Care Facilities Code, it was proposed that the word "selective" be removed under Sections 6.4.2.1.2 Selective Coordination (Type 1 EES) and Sections 6.5.2.1.1 Selective Coordination (Type 2 EES)



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