Selective Coordination

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Course Outline

- Definition of Selective Coordination
  - Guiding Code Requirements
- Why is Selective Coordination Important
- Which Overcurrent Devices Need to Be Selectively Coordinated?
  - How to Selectively Coordinate with Fuses?
  - How to Selectively Coordinate with Circuit Breakers?
- How to Comply with Selective Coordination
  - Analysis Methods
  - OCPD Choices & Trade-Offs
- Myths About Selective Coordination
- Compliance Process
What is Selective Coordination?
Selective Coordination Requirements

1993 NEC Articles
- 620 Elevator Circuits

2005 NEC Articles
- 700 Emergency Systems
- 701 Legally Required Standby Systems
- 517 Healthcare Facilities

2008 NEC Articles
- 708 Critical Operations Power Systems
Guiding Code Requirements

Selective Coordination requirements 2008/2011 NEC

- 100 Definition: Coordination Selective (2005-11)
- 620.62 Required for Circuits with multiple Elevators (1993)
- 700.9(B)(5)(b) Exception. OCPDs permitted at alternate source or for equipment (2008)
Selective Coordination is Defined by NEC 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.
What is Selective Coordination

- For the full range of possible overcurrents
- Only closest upstream OCPD from overcurrent opens
- Other upstream (larger) overcurrent protective devices do not open
Example

Without **Selective Coordination**

- **OPENs**
- **NOT AFFECTED**
- **UNNECESSARY POWER LOSS**

With **Selective Coordination**

- **OPENs**
- **NOT AFFECTED**
Why is Selective Coordination Important?
Why is Selective Coordination Important?

Answer:

- Increases system reliability to deliver power
- Focus on the load! Availability of power to vital loads as long as possible
- Life Safety
- Public safety and national security
  - By maintaining Critical Operations and Power Systems (COPS)
- Increases system reliability to power vital loads even during emergencies and disasters
- Facilitates restoration of power to affected loads
Article 700 Emergency Systems

- 700.27 Coordination
  - includes 517 healthcare essential electrical systems

- Emergency system(s) overcurrent devices shall be selectively coordinated with all supply side overcurrent protective devices
  - Two exceptions apply for 700.27 and 701.27
  - Wording for 701.27 and 708.54 is the similar except for the type system
Which Overcurrent Devices Need to Be Selectively Coordinated?
Which Overcurrent Devices Need to Be Selectively Coordinated?

Answer: All Overcurrent Devices

- Required for Circuits with multiple Elevators (1993)
- Required for Legally Required Standby Systems (2005)
Selective Coordination

Which Overcurrent Devices Need to Be Selectively Coordinated?

**Answer: All Overcurrent Devices**

- Required for Circuits with multiple Elevators (1993)
- Required for Legally Required Standby Systems (2005)
NEC 700.27 Coordination.

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

**Question:**

- Which “overcurrent devices” are emergency system overcurrent devices in this system?
NEC 700.27 Coordination.

- Emergency system(s) overcurrent devices shall be selectively coordinated with all supply side overcurrent protective devices

Answer:

- ALL overcurrent devices on the load side of the emergency source are emergency system overcurrent devices!
NEC 700.27 Coordination.

- Emergency system(s) overcurrent devices shall be selectively coordinated with all supply side overcurrent protective devices

Question:
- Which are overcurrent protective devices in the normal source path that supply the emergency system?
NEC 700.27 Coordination.

- Emergency system(s) overcurrent devices shall be selectively coordinated with all supply side overcurrent protective devices

- Emergency system overcurrent devices

- Normal system overcurrent devices that are supply side overcurrent devices for emergency system overcurrent devices

- Normal system overcurrent devices
NEC 700.27 Coordination.

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

Answer:

- Red-striped emergency system overcurrent devices must selectively coordinate with all blue-striped supply side normal system overcurrent protective devices as required in 700.27.

emergency system overcurrent devices

Normal system overcurrent devices that are supply side overcurrent devices for emergency system overcurrent devices
700.27 “Emergency system(s) overcurrent devices shall be selectively coordinated with all supply side overcurrent protective devices”

This wording is inclusive of the alternate path and normal source path overcurrent devices for each emergency load.

Practical Application Requirement Example:

- 1 must selectively coordinate with 2, 3, 4, 5, 6
- 2 must selectively coordinate with 3, 4, 5, 6
- 3 must selectively coordinate with 4
- Does 5 have to be selectively coordinate with 6?
  - By the strict wording of the requirements, 5 does not have to selectively coordinate with 6 because neither device is part of the emergency system
  - However, The wise decision is to be sure that 5 selectively coordinates with 6, even though it is not specifically required by 700.27.

Notation method: 1 represents OCPD device
Hashed OCPDs do not have to be selectively coordinated

**Exception 1:**
Transformer primary and secondary

**Exception 2:**
Two devices of same amp rating in series

Neither exception reduced life-safety because no additional parts of the electrical system would be shut down unnecessarily.
How to Selectively Coordinate with Fuses?
How to Selectively Coordinate with Fuses?

Answer:

Simply Follow the Fuse Manufacturer’s Selectivity Ratio

It is That Simple!!
Fuse Selectivity Ratio Tables

- Each fuse manufacturer has conducted fuse testing and analysis to develop a simple fuse type/ampere ratio method to select fuses that are selectively coordinated.

- Includes all overcurrent levels up to the fuses’ interrupting ratings (up to 200KA).

- Based on:
  - Fuse types lineside and loadside.
  - Meeting at least minimum ampere rating ratio between lineside/loadside fuses.
# Selective Coordination

(2005 SPD p 91 & 102)

<table>
<thead>
<tr>
<th>Circuit</th>
<th>Load Side Fuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Rating</td>
<td>Load-Side Fuse</td>
</tr>
<tr>
<td>Type</td>
<td>Time-Delay</td>
</tr>
<tr>
<td>Trade Name Class</td>
<td>Cooper Bussmann Symbol</td>
</tr>
<tr>
<td>Low-Peak (L)</td>
<td>KRP-C_SP</td>
</tr>
<tr>
<td>Limitron (L)</td>
<td>KLU</td>
</tr>
<tr>
<td>Low-Peak (RK1)</td>
<td>LPN-RK_SP</td>
</tr>
<tr>
<td>Limitron (RK1)</td>
<td>LP-RK_SP</td>
</tr>
<tr>
<td>Fusetron (RK5)</td>
<td>LPJ-SP</td>
</tr>
<tr>
<td>Fusebox (RK5)</td>
<td>T-Tron (T)</td>
</tr>
<tr>
<td>Limitron (RK1)</td>
<td>KTU</td>
</tr>
<tr>
<td>Limitron (RK1)</td>
<td>KTN-R</td>
</tr>
<tr>
<td>Limitron (RK1)</td>
<td>KTS-R</td>
</tr>
</tbody>
</table>

*Note: At some values of fault current, specified ratios may be lowered to permit closer fuse sizing. Plot fuse curves or consult with Cooper Bussmann.

**LOW-PEAK® : LOW-PEAK®**

2:1 Line:Load Ratio

No plotting required!
Overloads or faults of any level up to 200,000A

Selectiv Coordinatiion achieved between these two fuses

400/100 = 4:1 only 2:1 needed
Fuse Selectivity Ratio Example 1

Overloads or faults of any level up to 200,000A

- Low-Peak® KRP-C-800SP
- Low-Peak LPJ-400SP
- Low-Peak LPJ-100SP

Loadside Fuse

<table>
<thead>
<tr>
<th>KRP-C_SP</th>
<th>LPJ_SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2:1</td>
<td>2:1</td>
</tr>
<tr>
<td>LPJ_SP</td>
<td>-</td>
</tr>
</tbody>
</table>

Selective Coordination achieved between these two fuses

800/400 = 2:1 only 2:1 needed

400/100 = 4:1 only 2:1 needed
What about branch circuit lighting panel applications?

Use the **Quik-Spec Panel** which has **Class J TCF** fuse branch circuit protection: 1A to 100A.
Selectively Coordinated?

Can not determine by time current curves for Isca greater than point of arrow

Only way to determine is testing of combination

No known testing
Fuse Feeding CB

- Selectively Coordinated?
- Selectively coordinate up to current where fuse curve intersects with CB
- This represents a fuse/circuit breaker series rated combination
How to Selectively Coordinate with Circuit Breakers?
How to Selectively Coordinate with Circuit Breakers?

Answer:

Do short-circuit current study and coordination study investigating various types and options of CBs for a specific project
Circuit Breaker Alternatives

Circuit Breaker Manufacturer

Circuit Breaker Type
MCCB
ICCB
LVPCB

Circuit Breaker Options (next slides)
1. Instantaneous trip (IT)
2. Instantaneous trip, coordination tables
3. Fixed high magnetic IT
4. Short time delay (STD) w/ IT override (MCCB/ICCB)
5. Short time delay (STD) w/o IT override (LVPCB)

Note: some options may require larger frame or different type CBs

Fault Current Available
Adjustable Instantaneous Trip CB

Allow adjustment of the instantaneous trip setting
Typically 5 to 12 times the ampere rating

Figure shows 100A CB

- Setting of $5X = 500A$
- or
- Setting of $10X = 1000A$
1. Circuit Breaker Instantaneous Trip

Up to where the circuit breakers cross, it is interpreted to be coordinated. See ↑

- 800A
- 200A
- 30A

- Up to 7600A
- Up to 1500A
- 0.01s
- 0.1s
Table 1: UL 240 Vac QO/B Selective Coordination

<table>
<thead>
<tr>
<th>Max. Continuous Current Rating</th>
<th>Type</th>
<th>QO/B³</th>
<th>QO/B-VH³</th>
<th>QH/B³</th>
<th>QO/B-GF/EPD</th>
<th>QO/B-VHGF/EPD</th>
<th>QO/B-AFI</th>
<th>QO/B-VHAFI</th>
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<tr>
<td>kAIR¹</td>
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<td></td>
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<tr>
<td>25</td>
<td>HD</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
<td>0.9</td>
<td>1.3</td>
<td>1.3</td>
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<td>FH</td>
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<td>1.3</td>
<td>1.3</td>
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<td>0.9</td>
<td>1.3</td>
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<tr>
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<td>HG²</td>
<td>1.3</td>
<td>1.3</td>
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<td>1.3</td>
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<td>NT-H</td>
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<td>65</td>
<td>H²</td>
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<td>125</td>
<td>H²</td>
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<tr>
<td>25</td>
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<td>65</td>
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<tr>
<td>100</td>
<td>JG²</td>
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<td>JG²</td>
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<tr>
<td>125</td>
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</table>

Table illustrates the selection of molded case CBs to achieve selective coordination.
CB Manufacturer’s Coordination Tables can help show coordination for higher fault current than simply plotting curves.

Example: 30A & 200A MCCBs

1500A Crossing Point Interpreting Curves

Max. 2700A: CB Mfg. Coordination Testing
The 200A CB is a fixed high magnetic instantaneous trip (IT) device. It will coordinate with the downstream 30A CB up to 3200A versus 1500A for a conventional 200A CB.

1500A crossing point standard adjustable IT CB

3200A crossing point fixed high magnetic CB
4. Coordination
STD with IT Override

- Insulated case CB with short-time delay (STD) and instantaneous trip override (protects CB)
- Short-time delay from 2,400A to 6,400A provides coordination
- Not Coordinated in short-circuit region above 6,400A due to instantaneous trip override
Simple CB Analysis Method

For circuit breakers having instantaneous trips, there is a simple method to determine the highest short-circuit current or short-circuit amps (Isca) at which CBs will selectively coordinate.

There is no need to plot the curves.

This method is applicable to the instantaneous trip only, not the overload element. This can be used as a first test in assessing if a system is selectively coordinated.

There may be other means to determine higher values of Isca where CBs selectively coordinate (such as manufacture’s tables), but this is a practical, easy method.
CB Simple Analysis Method

Information needed for each feeder and main CB:

1. CBs amp ratings or amp settings

2. CBs instantaneous trip settings (IT)
   - Most feeder and main CBs have adjustable IT settings: there are various ranges from 4 to 12X
   - Some CBs have fixed settings
     - Some newer feeder CBs have fixed IT set at 20X

3. CBs IT percentage (%) tolerance
   - If CB IT % tolerance not known, here are some worst case* practical rules of thumb:
     - Thermal Mag. (High Trip Setting): ± 20%
     - Thermal Mag. (Low Trip Setting): ± 25%
     - Electronic Trip Style: ± 10%

* based on numerous samples taken from leading manufacturers
CB Simple Analysis Method

Equation:
\[
\text{Isca Coord} < (\text{CB amp rating} \times \text{IT setting}) \times (1 - \frac{\% \text{tolerance}^*}{100})
\]

Example: 200A CB with IT set at 10X and ± 20% tolerance

\[
\text{Isca Coord} < (200 \times 10) \times (1 - \frac{20\%}{100})
\]

\[
\text{Isca Coord} < (2000) \times (1 - 0.20) = 2000 \times 0.8
\]

\[
\text{Isca Coord} < 1600A \quad \text{see graph on next slide}
\]

Result: For currents up to 1600A, the 200A CB will selectively coordinate with the downstream CBs in the instantaneous operation

Note 1: This does not consider the overload operation, but is a first test. If this test is successful, investigate the overload element coordination

Note 2: The tolerance is ±, however, for this simple method, only need to consider the – tolerance

Best to use actual CB % tolerance, otherwise use assumed worst case % tolerance
Simple Analysis Method

Example: 200A Thermal Magnetic MCCB

Low
IT = 5X
(1000A)

This is for
IT = 5X

± 25%

750A
1250A

High
IT = 10X
(2000A)

This is example from prior slide

± 20%

1600A
2400A
Simple Analysis Method Ex. 1

- Look at CB settings and assess whether CBs are coordinated
- No need to draw curves
- Assume tolerances shown

<table>
<thead>
<tr>
<th>Current (A)</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>800</td>
<td>10X</td>
</tr>
<tr>
<td>200</td>
<td>10X</td>
</tr>
</tbody>
</table>

800A IT 10X Electronic (± 10%)
Isca Coord < (800x10) x (1-0.10) = 7200A

200A IT 10X Magnetic (± 20%)
Isca Coord < (200x10) x (1-0.20) = 1600A
Simple Analysis Method Ex. 2

- Look at CB settings and assess whether CBs are coordinated
- No need to draw curves
- Assume tolerance shown

800A IT 10X Magnetic (± 20%)
Isca Coord < (800x10) x (1-0.20) = 6400A

200A IT 10X Magnetic (± 20%)
Isca Coord < (200x10 x (1-0.20) = 1600A
Simple Analysis Method

Use Simple Rule for CB Circuit Path Coordination Analysis (see next slide)

1000 A. MCCB
IT @ 6 X = ? A
± 10% Tolerance

400 A. MCCB
IT @ 10X = ? A
± 20% Tolerance

Coordinates to what feeder fault level?

100 A. MCCB
IT Non-Adjustable

Coordinates to what branch fault level?
Simple Analysis Method

Example: Instantaneous trip settings and tolerances *known*

<table>
<thead>
<tr>
<th>CB Amp</th>
<th>IT Setting</th>
<th>Known Tolerance*</th>
<th>Coord. Up To</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000A</td>
<td>6X</td>
<td>± 10%</td>
<td>5,400</td>
</tr>
<tr>
<td>400A</td>
<td>10X</td>
<td>± 20%</td>
<td>3,200</td>
</tr>
<tr>
<td>100A</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Suggest using specific CB tolerance, if not known, use worst case % tolerance

1000A IT = 6X
400A IT = 10X
100A
3200A
5400A
Results from Simple Analysis Method (see previous slide)

1000 A. MCCB
IT @ 6X = ? A
± 10% Tolerance

400 A. MCCB
IT @ 10X = ? A
± 20% Tolerance

Coordinates to what feeder fault level < 5400A

100 A. MCCB
IT Non-Adjustable

Coordinates to what branch fault level < 3200A
Selective coordination for all overcurrents up to the interrupting rating for each circuit breaker

Still need to plot curves to ensure there is no crossing of circuit breaker curves. Must have time settings with enough separation.
Circuit Breaker Choices

- Options and settings vary between CB Vendors
- Wide range of interrupting ratings (many models)
- MCCBs, ICCBs, LVPCBs
  - Different options available for each type
  - Different range of settings available
- Tested coordination tables for some CB to CB combinations
- Use larger frame or more sophisticated CBs to achieve selective coordination for higher available fault currents

Result:
- May be trial and error working between the manufacturer’s specs and commercial software coordination module
- Size and cost of equipment can increase
- Contractor has to spend the time ensuring the proper type CBs and options are installed and set correctly.
How to Comply with Selective Coordination
How to Comply

- Analysis Methods
- OCPD Choices & Trade-Offs
Analysis Methods

- **Fuses**
  - Use Selectivity Ratios

- **LVPCBs**
  - Short-Time Delay settings on feeders and main: sufficient separation
  - May need to plot curves (commercial package)

- **CBs with instantaneous trip settings**
  - CB manufacturer’s Coordination tables
  - Simple rules
    - Isca must not exceed each CB amp rating X IT setting (include tolerance factor)
  - Use commercial software packages and interpret properly
## Summary OCPD CHOICES

<table>
<thead>
<tr>
<th>Fuses</th>
<th>MCCBs/ICCBs</th>
<th>LVPCBs Short-Time Delay Settings (STD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Instantaneous Trip</td>
<td>Fix High Magnetic Instantaneous Trip</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Short-Time Delay With Instantaneous Override</td>
</tr>
<tr>
<td>Short-Circuit Current Calculations Needed</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease of Coordination Analysis</td>
<td>Simplest Use Ratios</td>
<td>Takes More Work (use one of below):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use CB Manufacturers' Coordination Tables</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use Simple Analysis Rules</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use Commercial Software Packages: Interpret Properly</td>
</tr>
<tr>
<td>Applicability to Systems Depending on Available Short Circuit Currents</td>
<td>All</td>
<td>Some (where Isca lower) (larger frame CBs may help)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Many (expands applicability)</td>
</tr>
<tr>
<td>Cost</td>
<td>Low to Medium</td>
<td>Low to Medium</td>
</tr>
<tr>
<td>OCPD Maintenance to Ensure Integrity</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Myths About Selective Coordination
Myth: Bolted short-circuits or high level fault currents don’t occur very frequently, so selective coordination should only be required for overload conditions

Fact:

- Bolted faults are not the only condition where higher fault currents can result
- Low impedance short-circuits (results in high fault current) can and do occur
- Higher level faults are more likely in fires, natural catastrophes, human caused catastrophes and other emergency situations
**Myth:** Selective coordination results in an increased arc flash hazard

**Fact:**

- **Lack** of selective coordination can *increase* the arc flash hazard for electrical workers
- Typically higher flash hazard closer to the service
- If OCPDs unnecessarily cascade open, the electric worker must unnecessarily work at higher levels in the system
Myth: Selective coordination results in greater equipment short-circuit damage when short-time delay is used

Fact:

- Equipment is now available with longer short-time withstand ratings (short-circuit current rating)

- With CBs, zone selective interlocking allows the upstream CB to open as quickly as possible, bypassing the short-time delay for all faults between the two CBs

- With current-limiting fuses, intentional short-time delay is not required for selective coordination. Therefore, short-circuits are taken off-line as quickly as possible; equipment damage is not increased.
Compliance Process
Requires
proper engineering,
specification and
installation
Engineer designs required systems to achieve selective coordination

- Selection of proper overcurrent protective devices and
- Provide proper documentation verifying selective coordination
Contractor

- Install overcurrent protection as specified
- Substitutions must be approved by designer and must be proven to meet requirements
Where to get assistance for CBs

- CB manufacturers have published documents on how to coordinate circuit breakers.
Questions?
A fault occurs on a motor branch circuit and *both* the branch circuit and feeder overcurrent protective devices open.

Are the branch circuit and feeder overcurrent protective devices selectively coordinated with each other?

Yes or No

Unnecessary outage

Unnecessary Power Loss

OPENS

NOT AFFECTED
A fault occurs on a feeder and the feeder and main overcurrent protective devices open.

Are the feeder and main overcurrent protective devices selectively coordinated in this case?

Yes or No
Selective coordination of overcurrent protective devices is required for emergency systems and legally required standby systems per sections:

A. 700.56 & 701.37
B. 700.27 & 701.18
C. 240.10 & 240.27
D. 800.45 & 800.46
In healthcare facilities, overcurrent protective devices are required to be selectively coordinated for critical branch, life safety branch, and equipment systems essential for life safety

True
or
False
With fusible systems, selective coordination can be designed by adhering to the fuse selectivity ratios. Curves and detailed analysis are not typically required if the ratio are met.

True

or

False
With circuit breaker systems, selective coordination can typically be designed in. It may require the use of specific types of circuit breakers with specific options and settings, short circuit current study and a coordination analysis of the circuit paths.

True
or
False
Question 8

Overloads or faults of any level up to 200,000A

Is this a selectively coordinated circuit path?

Yes or No
Overloads or faults of any level up to 200,000A

<table>
<thead>
<tr>
<th>Lineside Fuse</th>
<th>Loadside Fuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>KRP-C-SP 2:1</td>
<td>KRP-C_SP 2:1</td>
</tr>
<tr>
<td>LPJ_SP -</td>
<td>LPJ_SP 2:1</td>
</tr>
<tr>
<td>LP-CC-20 2:1</td>
<td>LPS-RK_SP 2:1</td>
</tr>
</tbody>
</table>

Is this a selectively coordinated circuit path?

Yes or No
Is this a selectively coordinated circuit path?

Yes or No

- 800A CB
  - STD @ 0.1 Seconds

- 100A CB
  - IT Non Adjustable

- 20A CB
  - IT Non Adjustable

Maximum fault current at 20A circuit breaker is 800A

Maximum fault current at 20A circuit breaker is 800A

800A CB

100A CB

20A CB

Maximum fault current at 20A circuit breaker is 800A

900A

Yes or No
Is this a selectively coordinated circuit path?

Yes or No

- 800A CB
  - STD @ 0.1 Seconds

- 100A CB
  - IT Non Adjustable

- 20A CB
  - IT Non Adjustable

Maximum fault current at 20A circuit breaker is 2500A.
Scenario 1

Pringle Switch
Class L Fuses

Eaton
Square D QED-2/QMB
GE Spectra Fusible
Class RK1, J Fuses

Bussmann
Quik-Spec
Coordination
Panelboard
Class J
Fuses

Normal
Source

Alternate
Source

Bussmann Fusible Disconnect
EFJ Series
Class J Fuses

COOPER Bussmann
Scenario 2

Normal Source

Alternate Source

Pringle Switch
Class L Fuses

Eaton
Square D QED-2/QMB
GE Spectra Fusible
Class RK1, J Fuses

Bussmann
Quik-Spec
Coordination
Panelboard
Class J Fuses

Bussmann
Quik-Spec
Coordination
Panelboard
Class J Fuses

Panel 30 amp

60 amp Panel

COOPER Bussmann
Difficult to Coordinate!
Are these lighting Loads?
Are there other loads?
Can it be 480/277?
Proposal 13-135 proposed the elimination of the selective coordination requirement for 700.27 and moving the language to a fine print note. Code Panel 13 rejected 9–4.

NEC® Panel 13 Statement: “This proposal removes the selective coordination requirement from the mandatory text and places it in a non-mandatory FPN. The requirement for selective coordination for emergency system overcurrent devices should remain in the mandatory text. Selective coordination increases the reliability of the emergency system. The current wording of the NEC is adequate. The instantaneous portion of the time-current curve is no less important than the long time portion. Selective coordination is achievable with the equipment available now.”

Reaffirm as requirement and not a FPN.
Comment 20-13, proposed deletion of the selective coordination requirement
Code Panel 20 rejected Comment 16–0

NEC® Panel 20 Statement:
“The overriding theme of Articles 585 (renumbered to 708) is to keep the power on for vital loads. Selective coordination is obviously essential for the continuity of service required in critical operations power systems. Selective coordination increases the reliability of the COPS system.”

Reaffirms selective coordination required for system reliability
Quik-Spec™ Coordination Panelboard

600Vac / 400A with fusible and non-fusible main or MLO

50kA, 100kA & 200kA SCCR

Load Side Disconnect Available

Isolated or non-isolated ground option

200A or 400A Neutral option

Feed-through and sub-feed through lugs option

NEMA 1 & 3R

Surface and flush mount

Top and bottom feed

Door-in-door options

20” Width x 50” to 60½” height x 5 ¾” depth

Single “QSCP” Part Number

18, 30 & 42 Branch circuit positions with space options available

Finger-safe CUBEFuse® CCPB for branch circuit protection

Up to 100A branch circuits with 1-, 2- and 3-pole options

Removable branch knockouts

Spare fuse holder with spare fuses included with each panel

Advance shipment of boxes available
CCPB CUBEFuse® Branch Disconnects

- **Compact Circuit Protector Base (CCPB)**
  - UL Listed fusible branch disconnect (1-, 2- and 3-pole)
  - Ampacity-rejection prevents overfusing with breaks at 15A, 20A, 30A, 40A, 50A, 60A, 70A, 80A, 90A, 100A
  - Interlock prevents fuse removal while energized
  - Bolt-in design for quick installation to bus
  - Local open fuse indication on CCPB base
  - Lockout/Tagout provisions
  - Lock-On provisions

- **Low-Peak CUBEFuse Benefits**
  - Finger-safe
  - Smallest footprint of any class fuse on the market
  - Meets Class J time-delay electrical performance for UL/CSA
    - 600Vac voltage rating
    - UL Listed 300kA interrupting rating
    - Up to 200kA assembly SCCR rating
  - Reduces Arc Flash hazards and minimizes damage to equipment and circuits when sized properly
  - Optional easyID™ open fuse indication

**Safety & Convenience in a Small Footprint**
## Comparison – CB Panels

<table>
<thead>
<tr>
<th>Panel Configuration</th>
<th>Quik-Spec™ Coordination Panelboard</th>
<th>Circuit Breaker Branch Circuit Panelboards</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCCR</td>
<td>50kA</td>
<td>200kA</td>
</tr>
<tr>
<td>Voltage</td>
<td>600V</td>
<td>600V</td>
</tr>
<tr>
<td>Type</td>
<td>MLO</td>
<td>MLO</td>
</tr>
</tbody>
</table>

### Selective Coordination Analysis

- **Short-circuit current study required**
  - No (if fault level below 200kA)
  - Yes (must calculate available fault current at each point circuit breakers are applied)

- **Ease of achieving selective coordination**
  - Simplest (use fuse ratios)
  - Requires plotting time-current curves and proper interpretation. Limited to low available fault currents unless more sophisticated upstream circuit breakers are used

- **Study is job specific**
  - Not specific (all systems up to 200kA)
  - Yes (coordination scheme is typically not transferable)

- **Study applicable if fault currents change**
  - Yes (up to 200kA)
  - No (must re-verify selective coordination)

### Additional Features

<table>
<thead>
<tr>
<th>Size</th>
<th>20” W x 5-3/4” D</th>
<th>20” W x 5-3/4” D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branch fuse/CB interrupting rating</td>
<td>300kA</td>
<td>10kA</td>
</tr>
<tr>
<td>Panel SCCR</td>
<td>50kA</td>
<td>200kA</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>$$$</td>
<td>$$$</td>
</tr>
</tbody>
</table>
Selective Coordination and Transfer Switch Protection

WCR = Withstand and Closing (Close on) Rating (analogous to SCCR)

Options for Protection: CB or Fuse

- Protection with CBs
  - 3 types of ratings:
    - Specific Breaker Rating
    - 3 Cycle “Any Breaker” Rating
    - Short Time Rating (18-30 Cycle Rating)

- Or Protection with Fuses
Specific Breaker Ratings:

- **Combination Rating for specific ATS/CB**
  
  - **Issues:**
    - Initial Coordination
    - Added stress on contractor, consultant, inspector
    - Future Replacement
    - TCC of CB could change
ATS is umbrella tested for use with any instantaneous trip CB when used within its applied ratings

ATS can withstand a given fault current for 3 cycles (for ATS less than 400A, 1.5 cycles)

- Issues:
  • What if instantaneous breaker is designed but adjustable trip settings are changed in the field on a breaker?
  • What about selective coordination and short time delays?
“Any breaker” ATS protection...

- The transfer switch shown here was subjected to its maximum withstand rating for a duration of 3 cycles.

- This switch PASSED the UL 1008 test.

- According to UL 1008 an instantaneous trip breaker provided adequate protection. Do you agree? How about the customer that needs to purchase a new switch?

- Since safety, not performance, is the intent of the UL short circuit test, one should avoid stressing the device to its limits.

Instead use **current limitation** to reduce the let through energy during a fault.
Short Time Delay Breakers

- **ATS is tested to withstand faults of a given magnitude for (18-30 Cycles)**
- **This assures ATS can withstand faults on systems with breakers that have short time delays**
  - **Issues:**
    - Costly when compared to regular ATS of similar amp size
    - Many Short Time Ratings are only self certified
What else determines an ATSs WCR when using a circuit breaker?

- ATS Manufacturer (A,R,Z,C, C/E,K)
- ATS Series (i.e. 300,4000,7000)
- Voltage (240,480,600)
- Frame size (amp rating)
- Bypass/Non Bypass
- # of poles (2,3,4)
- Type of neutral (solid, switched, overlapping)
- Connection type (front/rear, mechanical/compression lugs)
- And More!
WCR when protected by a fuse?

- ATS amp rating dictates the WCR
- Use fuse class and max amps
- In almost all cases ATs 40-4000A have 200kA WCR (SCCR) rating
Example Problems

- A short circuit occurs downstream of a transfer switch where there is 43kA of available fault current.

1. What amount of fault current can an “any breaker” (3 cycle) rated ATS be subjected to when protected by a CB rated 65KAIC?

2. Looking at the chart what must the WCR of the ATS be? What is the minimum amp size ATS that can be used when protected by an instantaneous trip CB? (next slide)

3. Now what if there is a short time delay of 10 cycles on the upstream CB and we need a Short time rated ATS? Pick the correct ATS?

4. Finally what if a fused switch was protecting the ATS, find the smallest amp size ATS that would be protected.

If we had a 70A ATS what is the maximum fault current.
# Example WCR Chart

## Withstand and Close-On Ratings for all 7000 Series Products

<table>
<thead>
<tr>
<th>Switch Rating (Amps)</th>
<th>UL 1008 Withstand and Close-On Ratings (RMS Symmetrical), A</th>
<th>Recommended Fuses</th>
<th>Short Time (RMS Symn), A</th>
<th>Duration (Cycles)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transfer Switches</strong></td>
<td><strong>Bypass Switches</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>N/A</td>
<td>60, J</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>70, 100, 125, 150</td>
<td>22,000 480V</td>
<td>200, J</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>200, 230</td>
<td>22,000 480V</td>
<td>300, J</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>260, 400, 600</td>
<td>42,000 600V</td>
<td>600, J</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>260, 400, 600</td>
<td>50,000 480V</td>
<td>600, J</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>800, 1000, 1200</td>
<td>800 1000, 1200</td>
<td>1600, L</td>
<td>36,000, 18</td>
<td></td>
</tr>
<tr>
<td>1600, 2000</td>
<td>1600, 2000</td>
<td>3000, L</td>
<td>65,000, 30</td>
<td></td>
</tr>
<tr>
<td>2600, 3000</td>
<td>N/A</td>
<td>4000, L</td>
<td>65,000, 30</td>
<td></td>
</tr>
<tr>
<td>4000</td>
<td>N/A</td>
<td>6000, L</td>
<td>65,000, 18</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

1) All WCR values above are tested in accordance with the requirements of UL 1008. See ASCO Publication 1128 for more WCR information.

2) Application requirements may permit higher WCR for certain size switches. Contact ASCO for guidance if available short circuit current exceeds the WCR shown in the table.

3) “Any” Breaker Ratings are based on 3 cycles for 260 - 4000A and 1.5 cycles for 30 - 230A Switches. Applicable to the Circuit Breakers with the instantaneous trip elements.

4) Short-Time Ratings are provided for the applications involving Circuit Breakers that do not have instantaneous trips for system coordination. Applicable to transfer switch design only.

5) Optional front connected service for 1600 and 2000A switches is limited to 85,000 A for “Any” Breaker Rating.

6) Withstand (non UL) test ONLY.

7) Limited to 35kA on switches with overlapping neutral.

8) At 480V; does not apply to Bypass designs.
Low-Peak Class J, Dual-Element Time-Delay Fuses

LPJ_SP

PROSPECTIVE SHORT-CIRCUIT CURRENT - SYMMETRICAL RMS AMPERES

INTEGRATED PEAK LET-THROUGH CURRENT IN AMPERES

LPJ_SP Fuse – RMS Let-Through Currents (kA)

<table>
<thead>
<tr>
<th>Prosp. Short C.C.</th>
<th>15</th>
<th>30</th>
<th>60</th>
<th>100</th>
<th>200</th>
<th>400</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>I_{RMS}</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>I_{RMS}</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>I_{RMS}</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I_{RMS}</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I_{RMS}</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I_{RMS}</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I_{RMS}</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: For \( I_{RMS} \) value at 300,000 amperes, consult Factory.

©2009 Cooper Bussmann
Job requires: Qty(5) Open Transition Bypass Isolation ATSs:
4 Pole, 600A, 480V, NEMA 1

Qty (1) J7ATBB3600N5C
Est. Cost: $15,000.00
Cost for (5) = $75,000.00

After analyzing available fault current it is determined there is 58kA available at the ATS. What will need to be the WCR of the ATS?

Well what is the WCR of the switch above?

Assume protection by an instantaneous trip CB and “any breaker” 3 cycle rated ATS (no short time delay required)
J7ATBB3600N5C is rated to withstand: **42kA for 3 cycle**

Need to Bump the switch up to the next frame size.

- **Look at the Chart find the next frame size:**
  - The next frame size **H 800-1200A**
  - What is the WCR for these switches? **50kA for 3 cycles**

We will again need to go to the next frame size…
Looking at the chart the next frame size is: G 1000-3000 (WCR 85-100kA 3 Cycle)

Requires: Qty (1) G7ATBB31000N5C

= Est. Cost per switch: $35,000.00
Cost for (5) = $175,000.00
Example Summary

When protected by instantaneous trip CB:
- Qty (5) G7ATBB31000N5C
- Cost: $175,000.00
- Dimensions (1) ATS: 38W x 91H x 60D

When protected by a fuse:
- Qty (5) J7ATBB3600N5C
- Cost: $75,000.00
- Dimensions (1) ATS: 34W x 85H x 28D

Additional cost =
  $20K per ATS x Qty (5) = $100,000.00+ to Owner
Additional floor space required = 20W x 160D

What if a short time delay rating was required? Costs increase even more!

Fuse protection eliminates the need for short time rated ATSs and protect transfer switches for faults up to 200,000 Amps.
Available fault currents are evaluated by calculation before hand.

What if the real world layout changes or varies from what was originally expected?

What if 48kA available short-circuit current was calculated but later system changes occur and the available short-circuit current changes to 52kA? Change order? Who pays?

Changes can happen in the design/install phase or during the life of the system.
## Quik-Spec™ Coordination Panelboard Specifications

### Mains:
- MLO (Main Lug Only)
- Fused Disconnect Switch
- Non-fused Disconnect Switch

### Voltage Ratings & Panel SCCRs:
- @ 600Vac: 200kA, 100kA, 50kA
- @ 125Vdc: 100kA, 20kA

### Panel Ampacities:
- 400A, 225A, 200A, 100A, 60A or 30A

### Branch Circuits:
- Circuits: Up to 18, 30 and 42
- Amps: 1A to 100A
- Type: 1-, 2- and 3-Pole

### Panel:
- Feed: Top & Bottom
- Mounting: Surface or Flush
- Door/Trim: Regular or Door-in-Door
- NEMA Ratings: 1, 3R, Class 1 Div 2.

### Neutrals:
- 200A, 400A and 800A Unbonded and Bonded

### Grounds:
- Non-Isolated or Isolated

### Spare Fuses:
- Spare Fuse Compartment Included

---

**Enclosure Sizes:** Standard Size Panelboard (20” W x 5 ¾ D x from 33 to 70.5 inches H)

Advance Shipment of Cans Available
## Comparison vs. CB Panels

<table>
<thead>
<tr>
<th>Quik-Spec® Coordination Panelboard</th>
<th>Circuit Breaker Branch Circuit Panelboards</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image.png" alt="Image" /></td>
<td><img src="image.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>Panel Configuration</strong></td>
<td><strong>Standard SCCR</strong></td>
</tr>
<tr>
<td><strong>SCCR Voltage Type</strong></td>
<td><strong>50kA</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>600V MLO</td>
</tr>
</tbody>
</table>

### Selective Coordination Analysis<sup>2</sup>

- **Short-Circuit Current Study Required**
  - No (if fault level below 200kA)
  - Yes (must calculate available fault current at each point CBs are applied)
- **Current Limiting?**
  - YES: 2-4 ms
  - Not Standard: +16 ms
- **Study is Job Specific**
  - Not Specific (all systems up to 200kA)
  - Yes (coordination scheme is typically not transferrable)
- **Study Applicable if Fault Currents Change**
  - Yes (up to 200kA)
  - No (must re-verify selective coordination)

### Cost

<table>
<thead>
<tr>
<th>Cost</th>
<th>$</th>
<th>$$</th>
<th>$</th>
<th>$$</th>
<th>$$</th>
<th>$$$</th>
<th>$$$$</th>
<th>$$$$$</th>
</tr>
</thead>
</table>

### Size

| Size | 20” W x 5-3/4” D | 20” W x 5-3/4” D |

### Branch Fuse/CB Interrupting Rating

| Branch Fuse/CB Interrupting Rating | 200kA | 10kA | 14kA | 25kA | 35kA | 65kA | 100kA |

### Panel SCCR

| Panel SCCR | 100kA<sup>1</sup> | 200kA<sup>1</sup> | 10kA | 14kA | 25kA | 35kA | 65kA | 100kA |
Fuses in Data Centers

- Reliability
- No Maintenance
- High Interrupting Rating
- Current Limitation
  - Protects sensitive IT equipment
  - Reduce arc flash hazard
- OCPD Coordination is simple
- Flexibility
- With spares on hand CubeFuse is plug and protect
Fusible Distribution Panel

Static Switch

UPS

Power Distribution Unit with Fusible Panelboard

Fusible Cabinet Distribution Unit

Fusible Panelboard utilizing Cooper Bussmann CCP Disconnect with TCF Fuses available 1 to 100A

Your Data Center Protected up to 200kA up to 600V
Various configurations, with UPS/static switch, transformer or transformerless, 415V, CB or fused distribution panel

Plug-In Busway

with LPJ-SP
LPS-RK_SP
KPR-C_SP
Fuses
1/10 to 6000A

Fusible Cabinet Distribution Unit

Fusible Plug-In Unit utilizing Cooper Bussmann CCP Disconnect with TCF
Fuses available 1 to 100A

Your Data Center Protected up to 200kA up to 600V

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