Power Generation

Applying Transfer Switch High WCR & Short-Time Rating To Simplify Electrical System Design

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April 29th, 2021

(1PDH issued by Cummins)

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Participants are encouraged to refer to the entire text of all referenced documents. In addition, when it doubt, reach out to the Authority Having Jurisdiction.

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Course Objectives

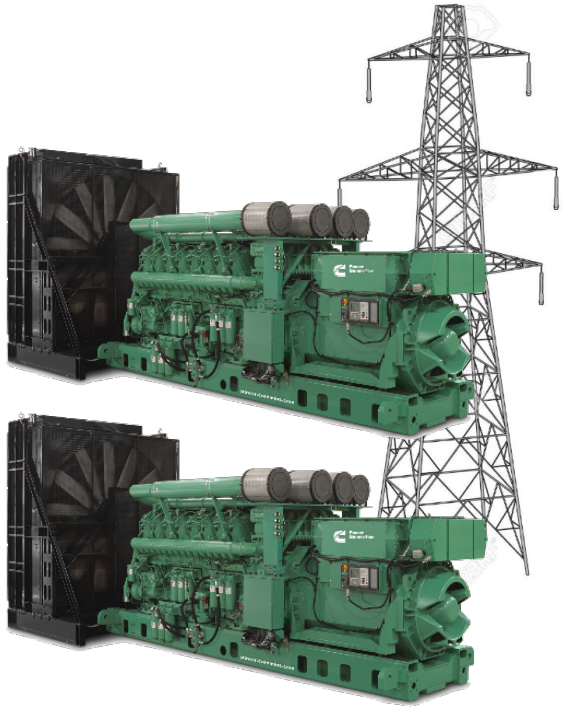
Applying Transfer Switch High WCR & Short-Time Rating To Simplify Electrical System Design

Transfer switches are critical components in the power system and they are tested to meet UL 1008 Standard for Safety - Transfer Switch Equipment. This course discusses some of the UL 1008 testing and passing criteria and then demonstrates that high short-circuit and short-time withstand and closing rating (WCR) help simplify the selection of overcurrent protection devices and enable selective-coordination strategies. This course also touches on switchboards (UL891) and switchgear (UL1558).

After completing this course, participants will be able to:

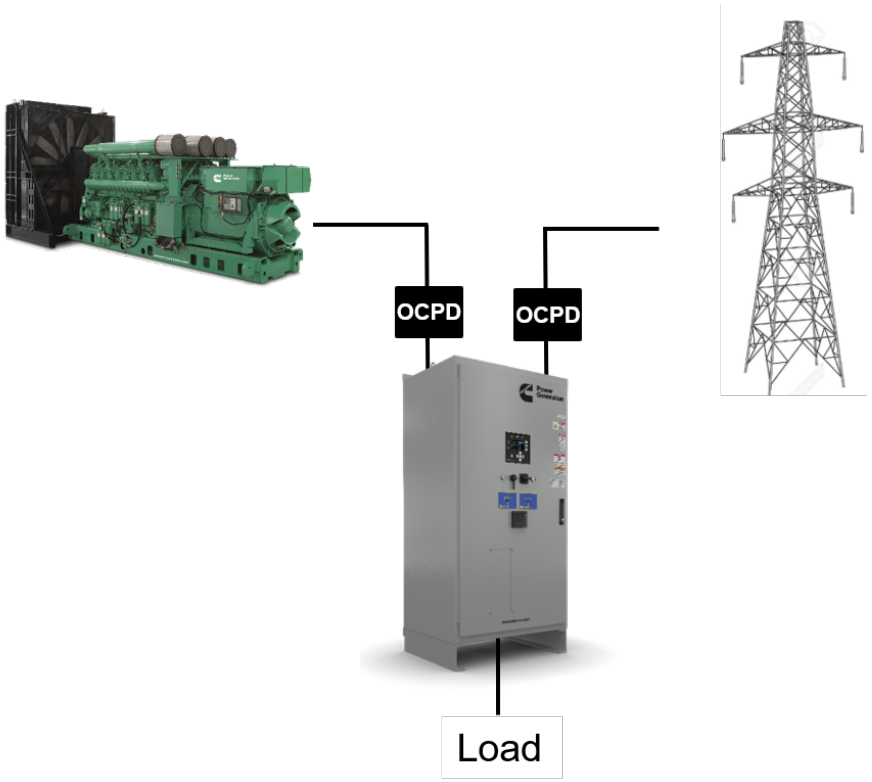
- Discuss the UL 1008 requirements for transfer switch withstand and closing ratings
- Discuss the difference between the short-circuit withstand/closing rating and the short-time rating
- Explain how the time based short-circuit WCR simplifies the selection of breakers
- Explain how the short-time WCR enable selective coordination strategies
- Discuss the major differences between switchboards and switchgear (UL891 and UL 1558)

Power System Components



Sources	Source Switching	Distribution Boards & Control	Remote Monitoring
Utility Generator sets	Transfer switches	Switchgear UL1558 Switchboard UL891 System level control	Diagnostics Compliance reports Push notifications

Simpler Systems



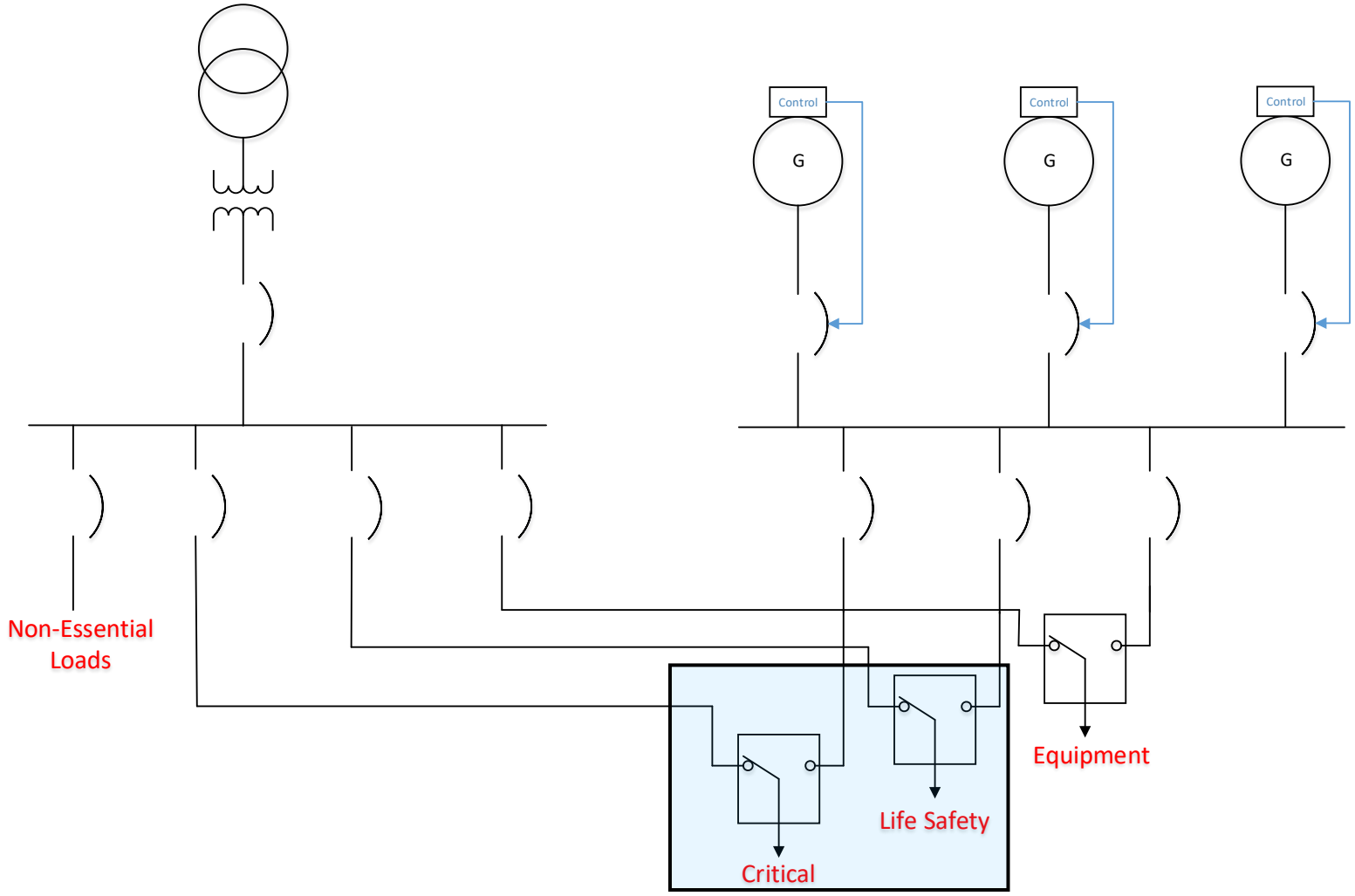
More Complex

OCPD: Overcurrent Protection Device

Today's Focus Is On Transfer Switches

Sources	Source Switching	Distribution & Control	Remote Monitoring
Utility Generator Sets	Transfer Switches	Switchgear UL1558 Switchboard UL891 System Level Control	Diagnostics Compliance Reports

Transfer Switches Are Critical In Power Systems



Key Considerations When Selecting A Transfer Switch

- Switch type (Automatic, Non-Automatic)
- Transition type (Delayed, Closed)
- Application (Utility-Gen, Gen-Gen, Utility-Utility)
- Grounding schemes (Separately Derived, Non-Separately Derived)
  - Drives 4-Pole or 3-Pole Transfer Switches
- Cable sizes and entry requirements (Top Entry, Bottom Entry)
- Enclosures (Type: 1, 3R, 4X, 12)
- Voltage/Frequency (600VAC, 480VAC / 50Hz, 60Hz)
- Current rating (3000A, 2000A, 800A)
- Fault current capability (WCR: 65kA, 85kA, 100kA)
- Selective coordination (WCR & Listed OCPD)
- Codes & Standards (UL/CSA, NFPA, NEMA, ISO, EN)

Understanding & Applying Transfer Switch Short-Circuit Ratings

SHORT-CIRCUIT WITHSTAND/CLOSING RATINGS AND SHORT-TIME CURRENT RATINGS

When protected by a circuit breaker, this transfer switch is suitable for use in a circuit capable of delivering the short-circuit current for the maximum time duration and voltage listed below.

The circuit breaker must include an instantaneous trip response unless the available short-circuit current is less than or equal to the short-time rating of the transfer switch and the circuit breaker includes a short-time response.

The maximum clearing time of the instantaneous trip response must be equal to or less than the time duration shown for the listed short-circuit current.

When protected by a circuit breaker with a short-time trip response, the short-time response of the circuit breaker must be coordinated with the short-time current rating of the transfer switch as listed below.

Short-Circuit Current (RMS Symmetrical Amperes)	AC Voltage (Maximum)	Time Duration (Maximum Seconds)
150000	600	0.050

Short-Time Current (RMS Symmetrical Amperes)	AC Voltage (Maximum)	Time Duration (Maximum Seconds)
125000	600	0.500

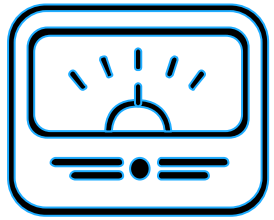
Fuse Rating

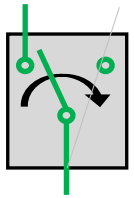
When protected by a fuse of the specific fuse class and up to the fuse amperes listed below, this transfer switch is suitable for use in a circuit capable of delivering up to the short circuit current and voltage listed below.

Short-Circuit Current (RMS Symmetrical Amperes)	AC Voltage (Maximum)	Fuse Class	Maximum Fuse Amperes
200000	600	L	4000

The Role Of Underwriters Laboratories

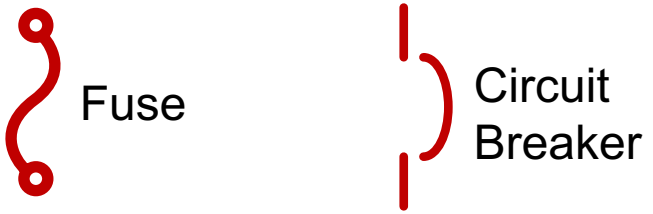
- UL1008 "Standard For Safety Transfer Switch Equipment"
- UL 1008 specifies stringent testing requirements
  - Temperature rise test
  - Dielectric voltage-withstand test
  - Overload test
  - Contact opening test
  - Endurance test
  - Short-circuit test
  - Dielectric voltage-withstand test (following short-circuit withstand/closing test)
  - Short-time current test (optional)

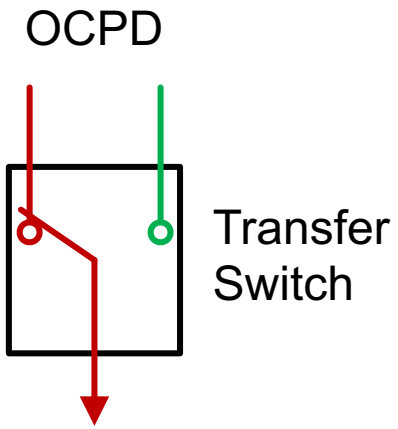




Clearing Vs. Withstanding A Fault

- Overcurrent Protection Devices (OCPD) clear faults
  - Fuses
  - Circuit breakers
- OCPDs have an Ampere Interrupting Capacity (AIC) rating
- The AIC rating is the maximum available fault current that an OCPD will safely clear when a fault is applied at the load side of the OPCD
- Transfer switches are not rated to clear faults, they are rated to withstand a fault
  - Therefore, transfer switches must be protected upstream by an OCPD
  - Transfer switches have a WCR





Transfer Switch Short-Circuit Rating

- Per UL 1008, transfer switches must:
  - Withstand the fault current
  - Close on the fault current
- Transfer switches have a short-circuit Withstand/Closing Rating (WCR)
- Withstand test (starts with contacts closed):
  - A specified fault current is applied for either:
    - A specific duration

      OR
    - Until a specific OCPD trips
- Closing test (starts with contacts open then close):
  - The same transfer switch must close onto the fault current under the same conditions used in the withstand test
- The same set of contacts are used for both tests: withstand and closing

UL 1008 Short-Circuit Test Requirements

Available Short-Circuit Current

Switch Rating (A)	Current* (A)	Power Factor*	Time Duration (s), minimum*
100 or less	5,000	0.40 - 0.50	0.008
101 - 400	10,000	0.40 - 0.50	0.025
401 - 1000	20x rating but not less than 10,000	0.25 - 0.30	0.050
1001 and greater	20x rating	0.20 or less	0.050
*Current can be higher, power factor can be lower, time durations can be different			

Duration:

Amount: Amperes

Data is from Tables 25 of UL 1008 8th edition

UL 1008 Short-Circuit Test Requirements

Available Fault Current Rating – RMS Symmetrical Amperes
5,000
7,500
10,000
14,000
18,000
22,000
25,000
30,000
35,000
42,000
50,000
65,000
85,000
100,000
125,000
150,000
200,000

Acceptable Short-Circuit Current Time Durations in seconds
0.008
0.017
0.025
0.033
0.050
0.067
0.083
0.100

Data is from Tables 1 & 27 of UL 1008 8th edition

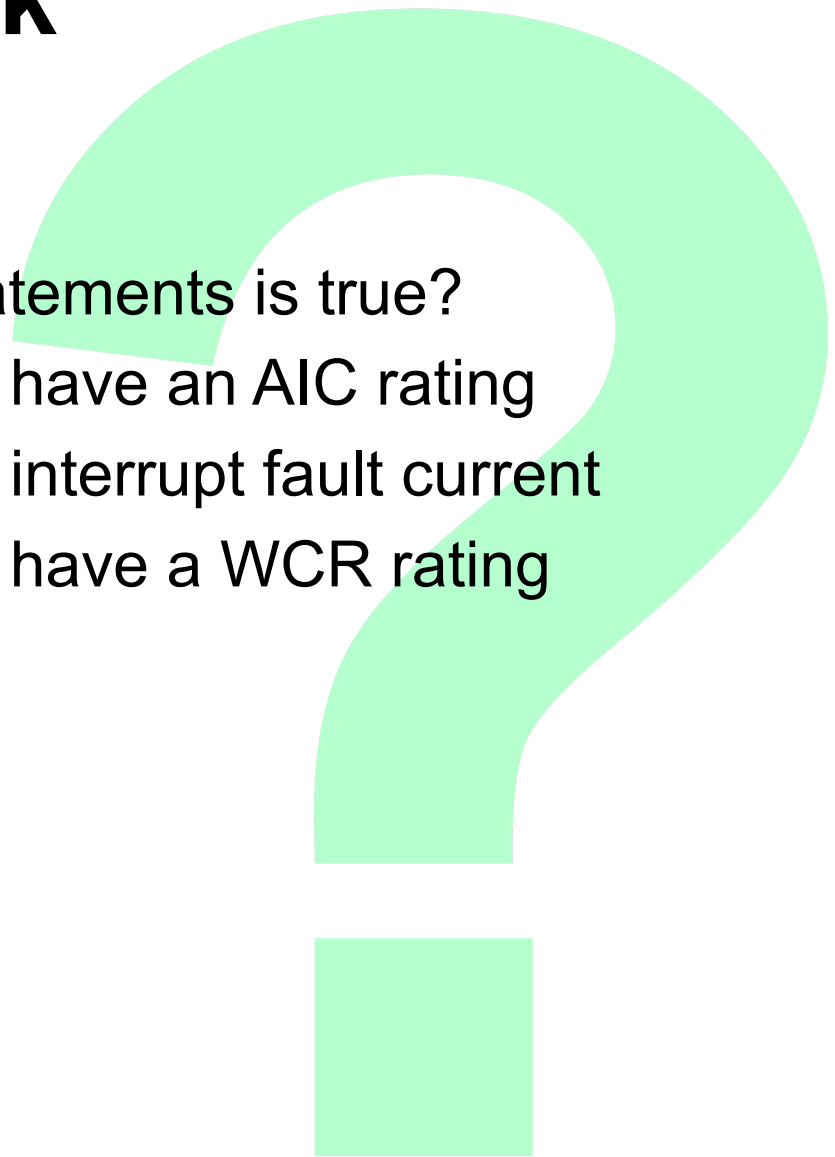
Short-Circuit WCR Passing Criteria

- Ability to operate the switch and close to the opposite source
- No breakage of switch base or any other internal parts
- Door must stay secure
- Cables stay connected to lugs without insulation damage
- No continuity between the normal and alternate source terminals
- Pass a dielectric voltage-withstand test

Concept Check

Which of the following statements is true?

a) Transfer switches have an AIC rating
b) Transfer switches interrupt fault current
c) Transfer switches have a WCR rating
d) All the above



Concept Check

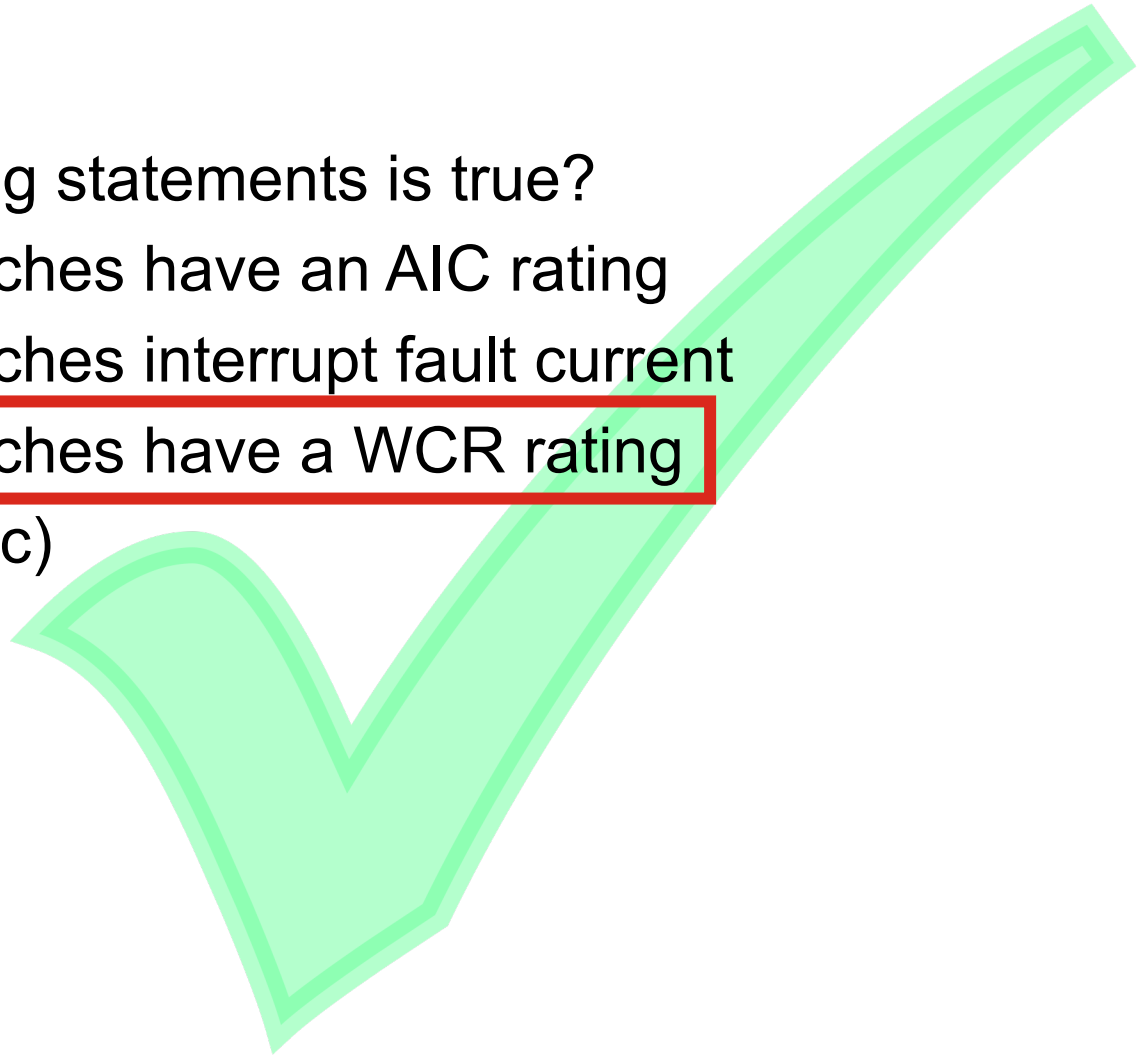
Which of the following statements is true?

a) Transfer switches have an AIC rating

b) Transfer switches interrupt fault current

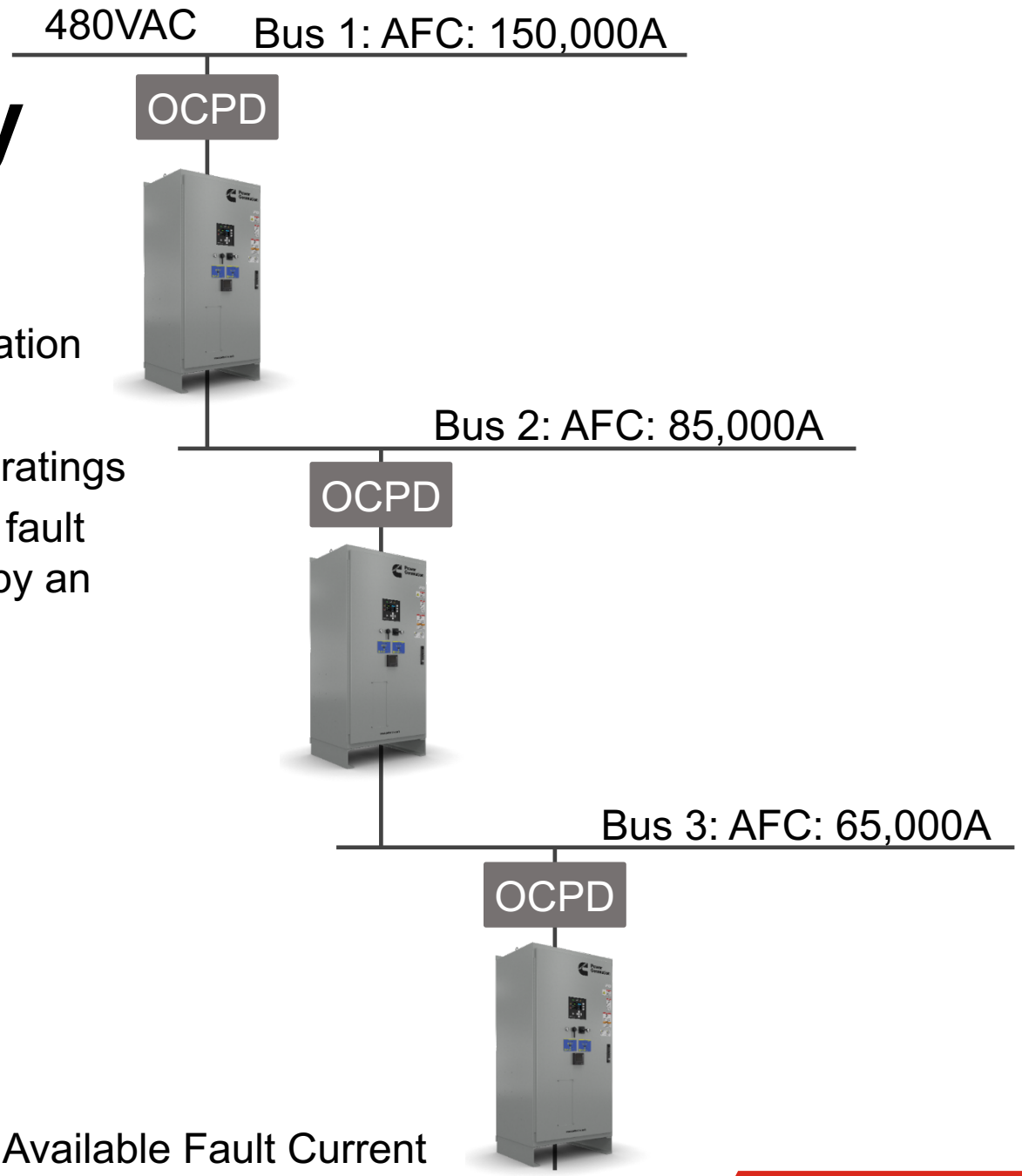
c) Transfer switches have a WCR rating

d) Both a) AND c)



Fault Current Capability

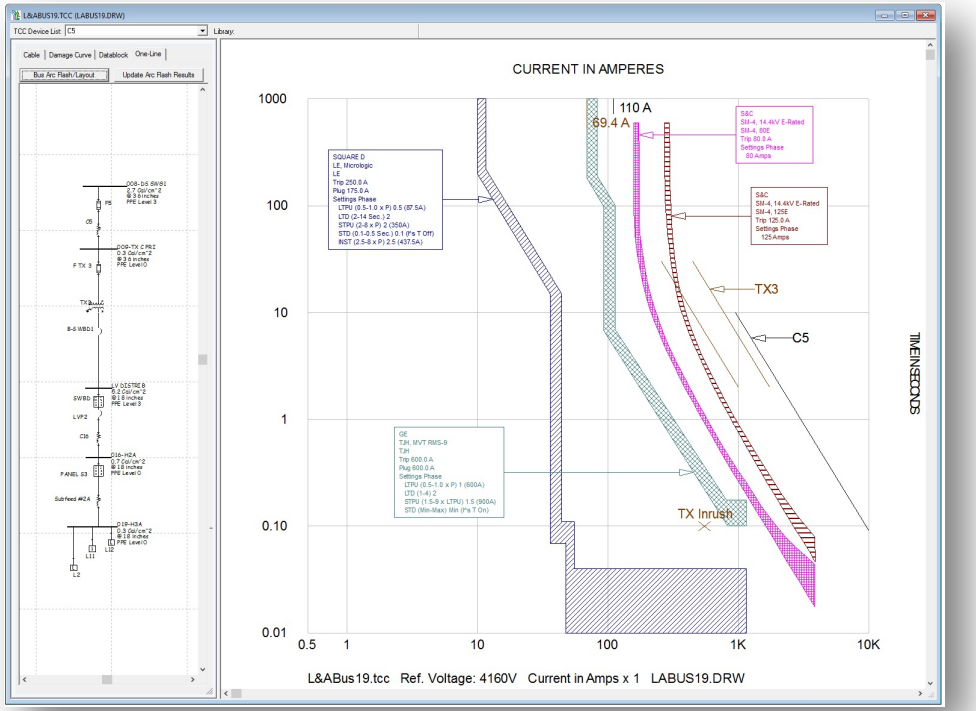
- Determine the available fault current at the switch location from the short-circuit analysis
- Select transfer switches with appropriate short-circuit ratings
  - Transfer switches must be rated for the available fault current at their line side terminals and protected by an OCPD selected appropriately
- Select appropriate OCPD
  - Time based: generic UL 489 circuit breaker
  - Specific breaker: tested with the transfer switch



AFC: Available Fault Current

Some Of The Challenges

- Detailed coordination studies haven’t been completed
  - Utility transformer hasn’t been selected
  - Equipment (transfer switch, conductors, etc.) must be braced for the fault current
- Unknown switchboard/switchgear OEMs and breaker selection
- Limited space in the electrical room
  - Transfer switch upsize to meet the short-circuit rating
- New breaker models from the OEMs
  - Transfer switch manufacturers may need to test with new the breakers per UL 1008 7th Edition



UL 1008 Change To Breakers

- Before UL1008 7th edition, a new breaker could be added by comparing the max published trip time with the max published trip time of the tested breaker

  MAX published trip time of new breaker

  ≤

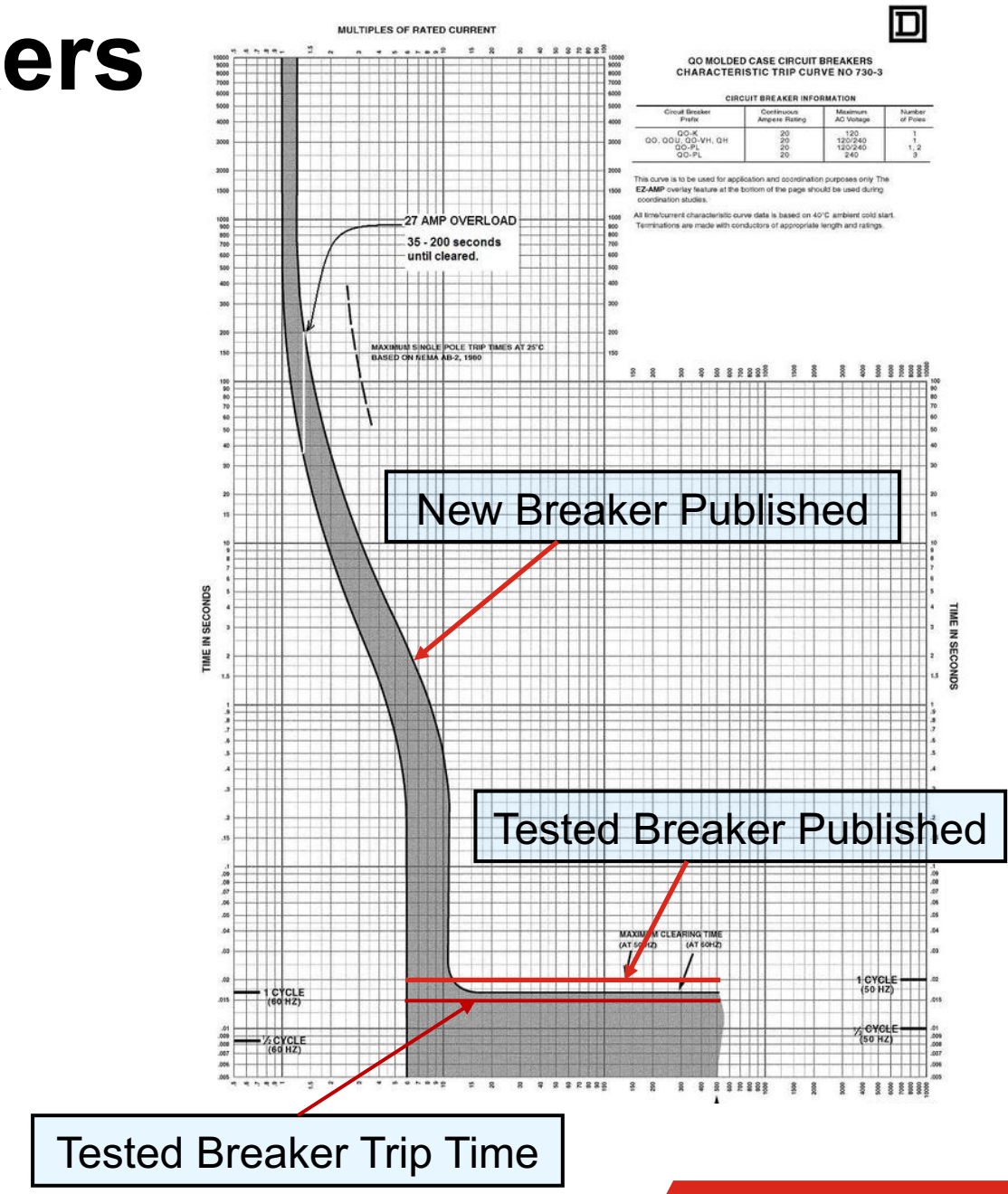
  MAX published trip time of tested breaker

- After UL1008 7th edition, a new breaker can be added by comparing the max published trip time with the tested trip time using the original breaker

  MAX published trip time of new breaker

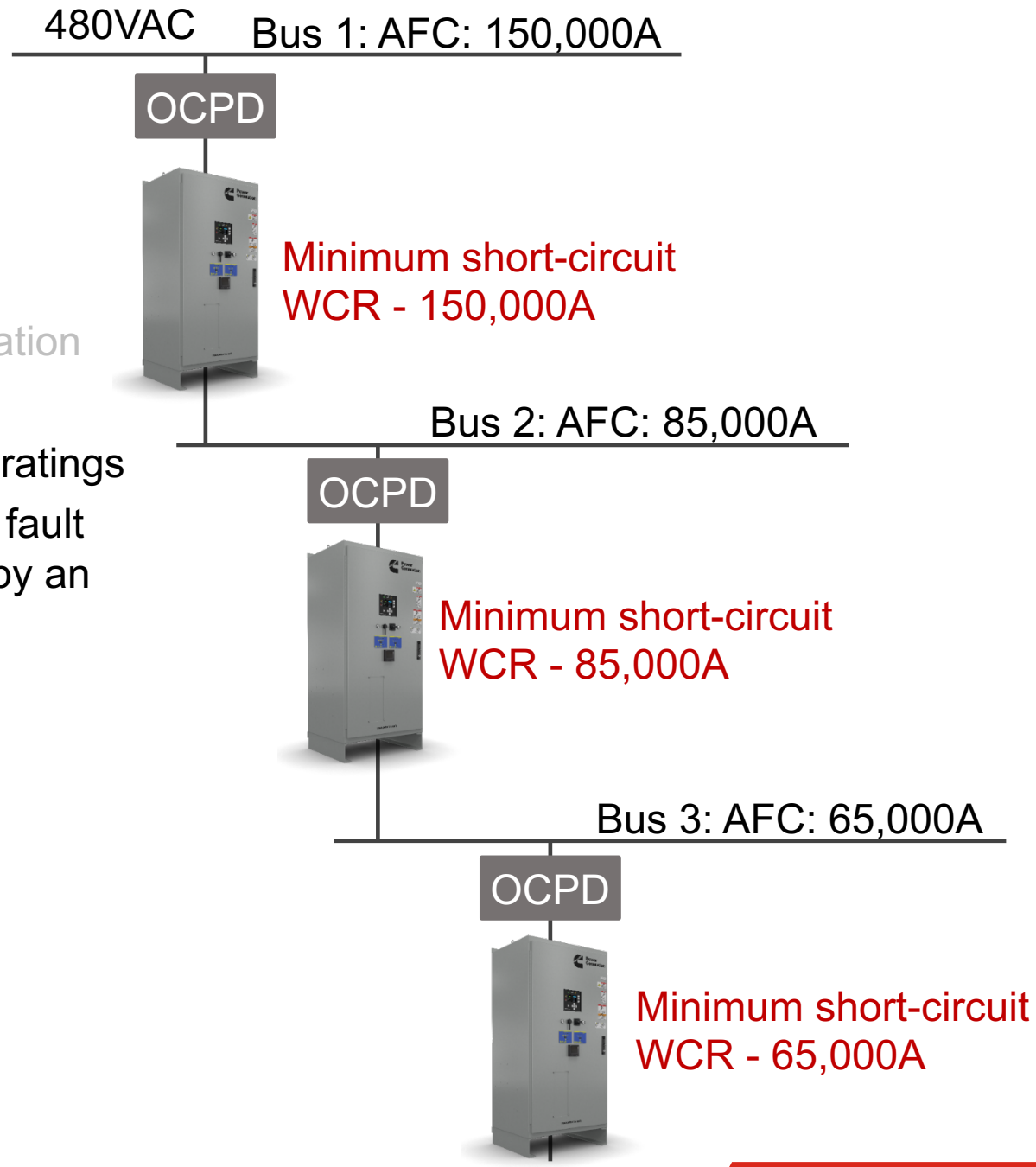
  ≤

  ACTUAL tested breaker trip time measured during the UL witness test



OCPD Selection

- Determine the available fault current at the switch location from the short-circuit analysis
- Select transfer switches with appropriate short-circuit ratings
  - Transfer switches must be rated for the available fault current at their line side terminals and protected by an OCPD selected appropriately
- Select appropriate OCPD
  - Time based: generic UL 489 circuit breaker
  - Specific breaker: tested with the transfer switch



Applying The Time Duration Rating

SHORT-CIRCUIT WITHSTAND/CLOSING RATINGS

When protected by a circuit breaker, this transfer switch is suitable for use in a circuit capable of delivering the short-circuit current for the maximum time duration and voltage listed below.

The circuit breaker must include an instantaneous trip response and shall not include a short-time trip response.

The maximum clearing time of the instantaneous trip response must be equal to or less than the time duration shown for the listed short-circuit current.

Short-Circuit Current (RMS Symmetrical Amperes)	AC Voltage (Maximum)	Time Duration (Maximum Seconds)
150000	600	0.050

Applying The Time Duration Rating

SHORT-CIRCUIT WITHSTAND/CLOSING RATINGS

When protected by a circuit breaker, this transfer switch is suitable for use in a circuit capable of delivering the short-circuit current for the maximum time duration and voltage listed below.

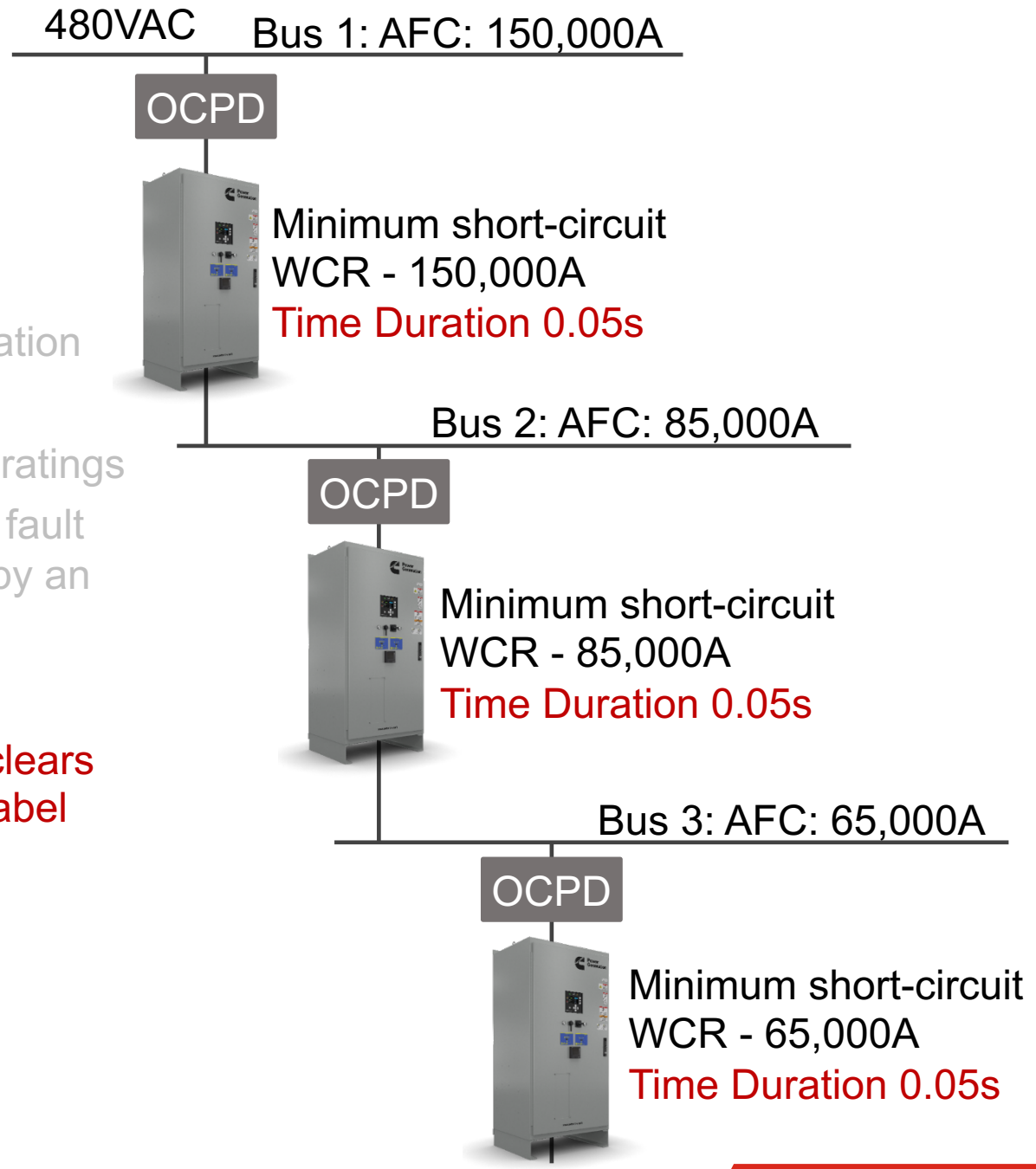
The circuit breaker must include an instantaneous trip response and shall not include a short-time trip response.

The maximum clearing time of the instantaneous trip response must be equal to or less than the time duration shown for the listed short-circuit current.

Short-Circuit Current (RMS Symmetrical Amperes)	AC Voltage (Maximum)	Time Duration (Maximum Seconds)
85000	600	0.050

OCPD Selection

- Determine the available fault current at the switch location from the short-circuit analysis
- Select transfer switches with appropriate short-circuit ratings
  - Transfer switches must be rated for the available fault current at their line side terminals and protected by an OCPD selected appropriately
- Select appropriate OCPD
  - Time based: generic UL 489 circuit breaker that clears the fault current within the time specified on the label
  - Specific breaker: tested with the transfer switch

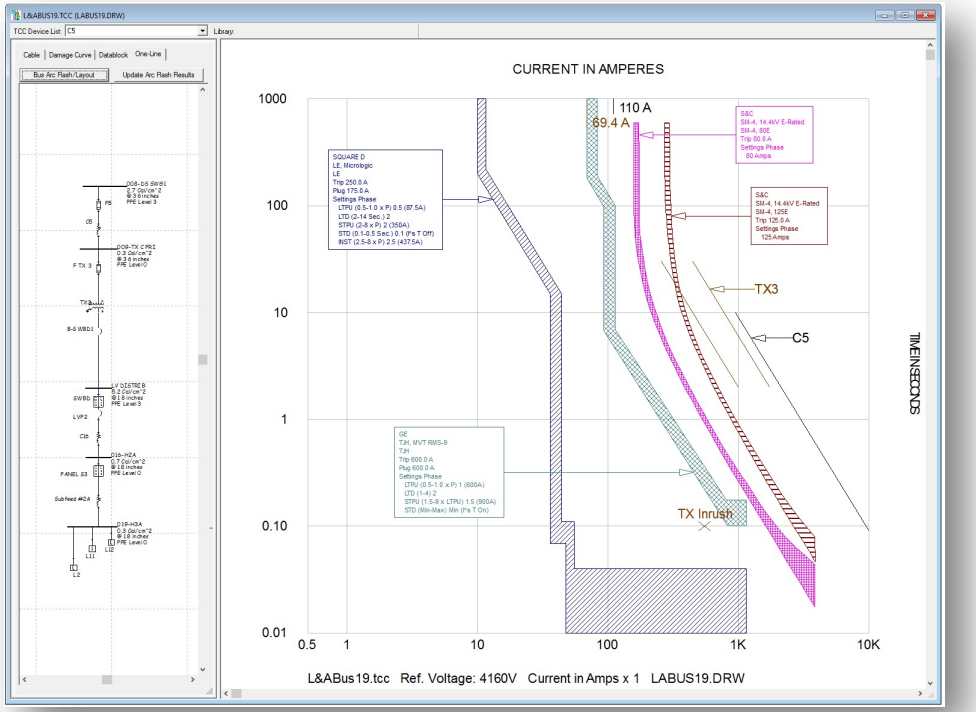


Some Of The Challenges

- Detailed coordination studies haven't been completed
  - Utility transformer hasn't been selected
  - Equipment (transfer switch, conductors, etc.) must be braced for the fault current

High time-based short-circuit withstand/closing ratings (WCR) simplifies breaker selection

- Unknown switchboard/switchgear OEMs and breaker selection
- Limited space in the electrical room
  - Transfer switch upsize to meet the short-circuit rating
- New breaker models from the OEMs
  - Transfer switch manufacturers may need to test with new the breakers per UL 1008 7th Edition



What Is The "Any Breaker" Rating?

- The term "Any Breaker" is another way to state the Time Duration rating
- UL 489 requires Molded Case Circuit Breakers (MCCB):
  - Above 400 amps to clear a fault in no more than 0.050s
  - 400 amps and below to clear a fault in no more than 0.025s

SHORT-CIRCUIT WITHSTAND/CLOSING RATINGS

When protected by a circuit breaker, this transfer switch is suitable for use in a circuit capable of delivering the short-circuit current for the maximum time duration and voltage listed below.

The circuit breaker must include an instantaneous trip response and shall not include a short-time trip response.

The maximum clearing time of the instantaneous trip response must be equal to or less than the time duration shown for the listed short-circuit current.

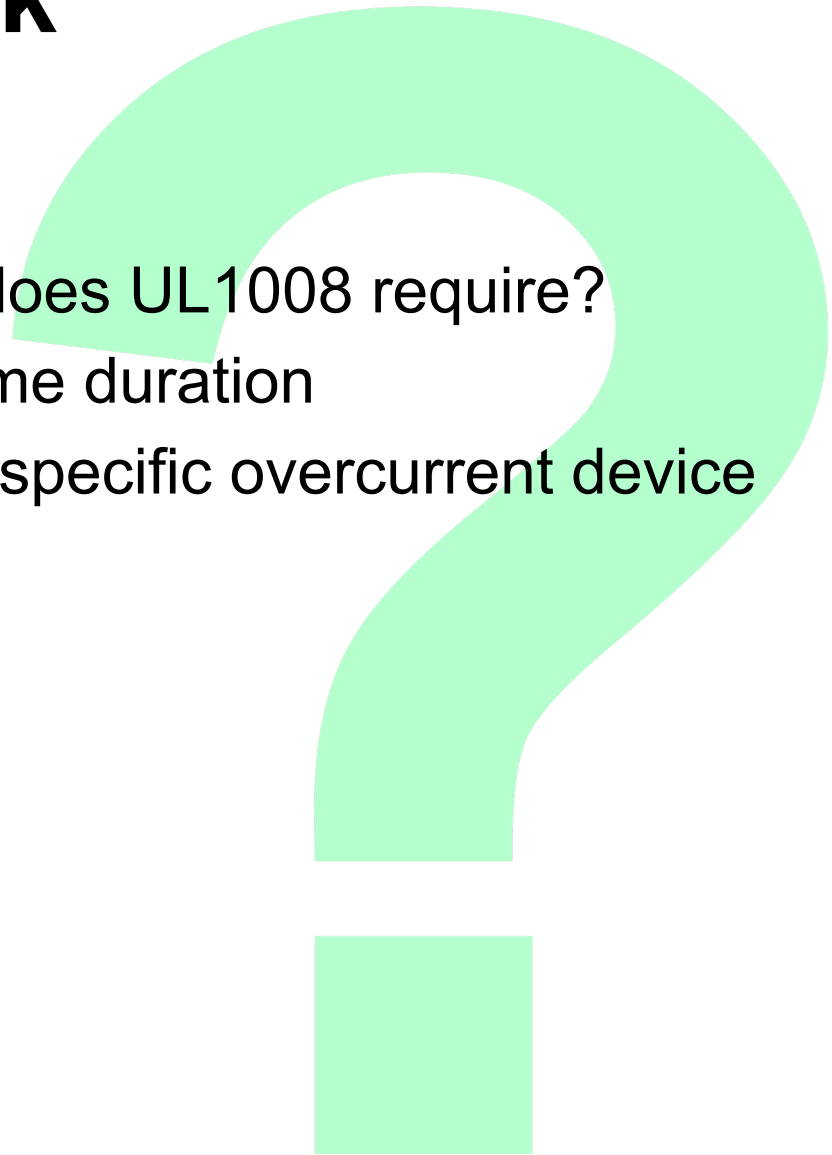
Short-Circuit Current (RMS Symmetrical Amperes)	AC Voltage (Maximum)	Time Duration (Maximum Seconds)
65000	600	0.050

Voltage: 480VAC
AFC: 65000A

Concept Check

What short circuit rating does UL1008 require?

a) WCR based on time duration
b) WCR based on a specific overcurrent device
c) Either a) OR b)
d) Both a) AND b)



Concept Check

What short circuit rating does UL1008 require?

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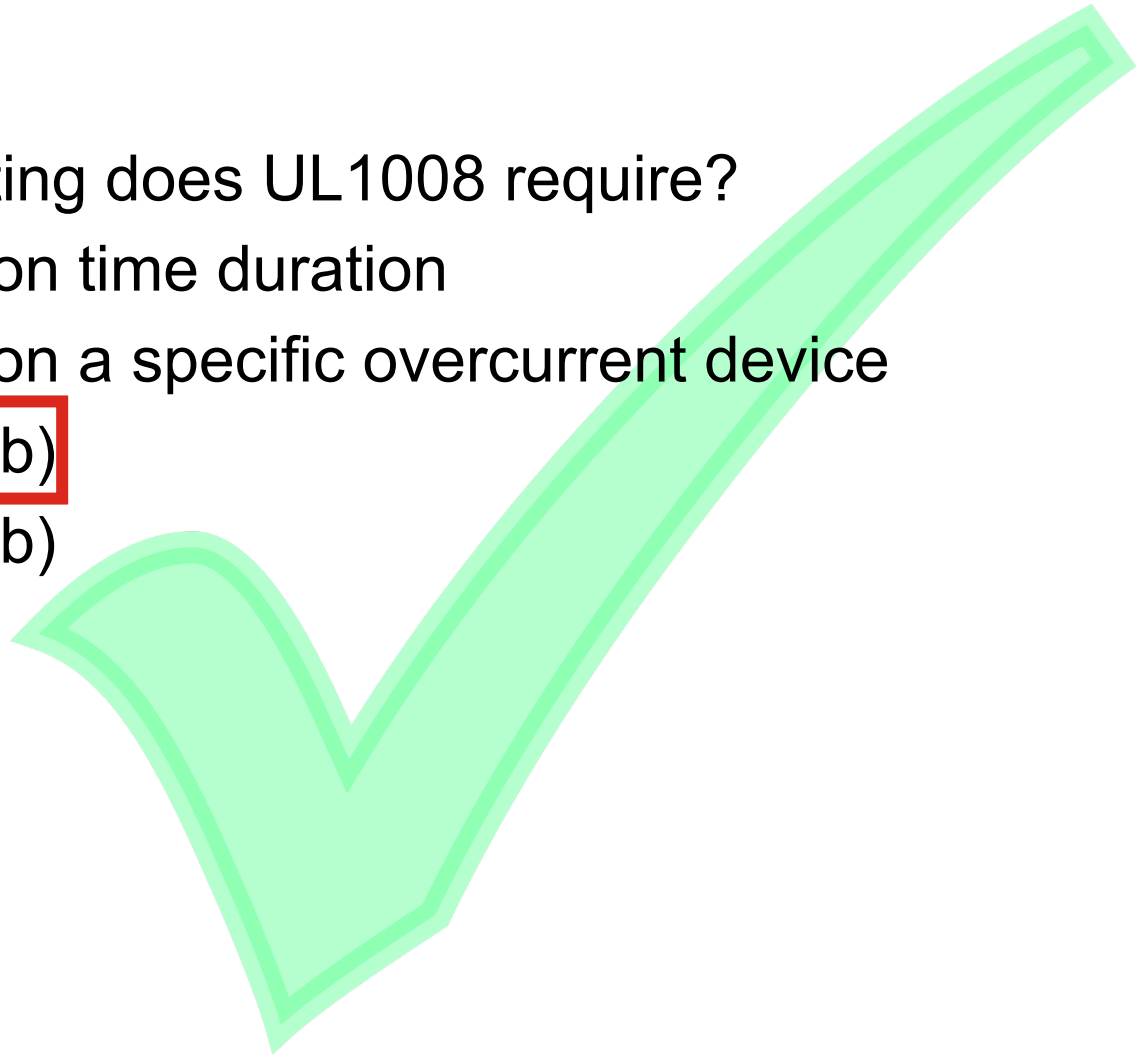


The Role Of Underwriters Laboratories

- UL1008 "Standard For Safety Transfer Switch Equipment"
- UL 1008 specifies stringent testing requirements
  - Temperature rise test
  - Dielectric voltage-withstand test
  - Overload test
  - Contact opening test
  - Endurance test
  - Short-circuit test
  - Dielectric voltage-withstand test (following short-circuit withstand/closing test)
  - Short-time current test (optional)

Short-Time Current Rating Test

- It is a Time Duration short-circuit WCR test
- Durations are set by the manufacturer. For example: 0.50s
- Transfer switch must pass the same criteria outlined before:
  - Ability to operate the switch and close to the opposite source
  - No breakage of switch base or any other internal parts
  - Door must stay secure
  - Cables stay connected to lugs without insulation damage
  - No continuity between the normal and alternate source terminals
  - Pass a dielectric voltage-withstand test
  - Pass a temp-rise test
- Short-Time demonstrates that the transfer switch can still carry rated current

UL LISTED

Applying The Short-Time Rating

SHORT-CIRCUIT WITHSTAND/CLOSING RATINGS AND SHORT-TIME CURRENT RATINGS

When protected by a circuit breaker, this transfer switch is suitable for use in a circuit capable of delivering the short-circuit current for the maximum time duration and voltage listed below.

The circuit breaker must include an instantaneous trip response unless the available short-circuit current is less than or equal to the short-time rating of the transfer switch and the circuit breaker includes a short-time response.

The maximum clearing time of the instantaneous trip response must be equal to or less than the time duration shown for the listed short-circuit current.

When protected by a circuit breaker with a short-time trip response, the short-time response of the circuit breaker must be coordinated with the short-time current rating of the transfer switch as listed below.

Short-Circuit Current (RMS Symmetrical Amperes)	AC Voltage (Maximum)	Time Duration (Maximum Seconds)
150000	600	0.050

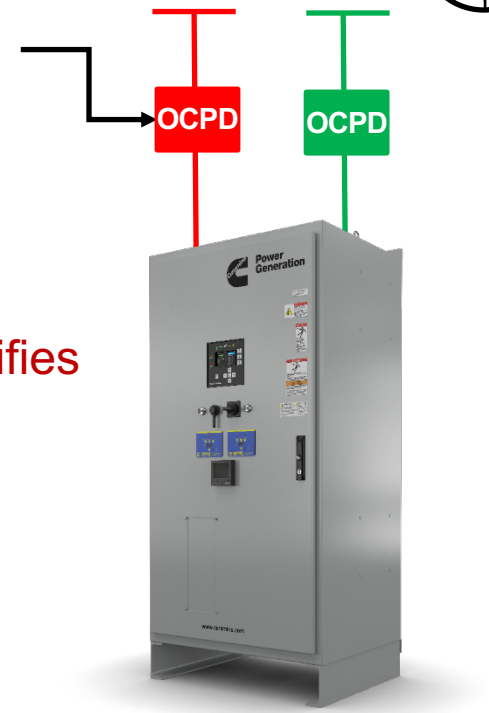
Short-Time Current (RMS Symmetrical Amperes)	AC Voltage (Maximum)	Time Duration (Maximum Seconds)
125000	600	0.500

UL LISTED

Voltage: 600VAC
AFC: 125000A
0.50 Duration

Breakers can have a short-time response:

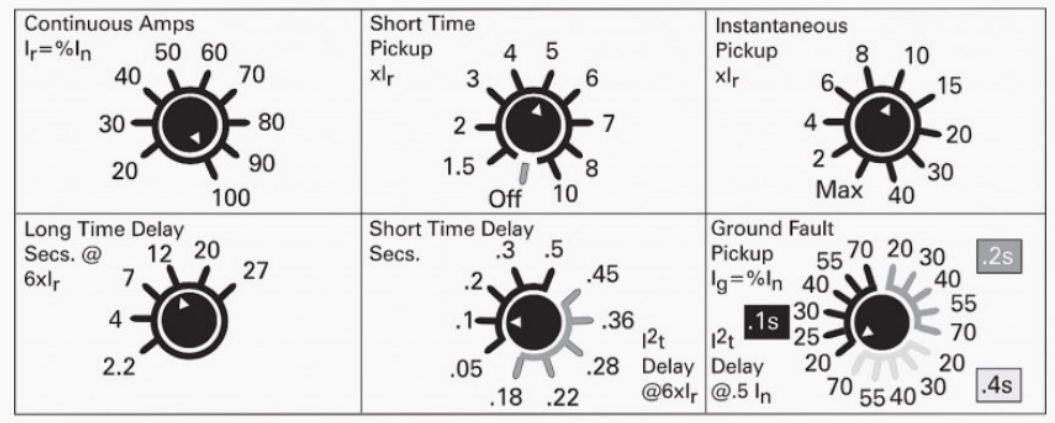
For example: UL1066 Breaker

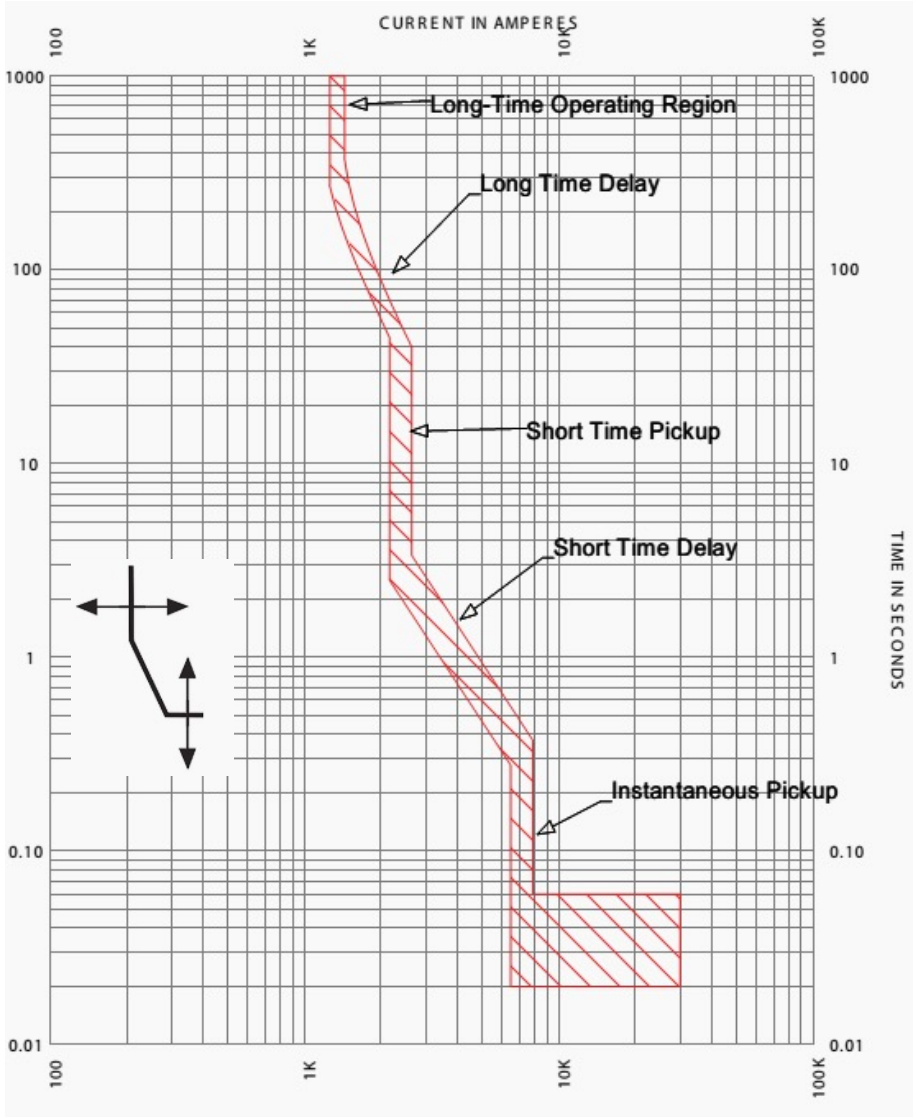


Short-Time rating simplifies selective coordination

Time-Current Curve

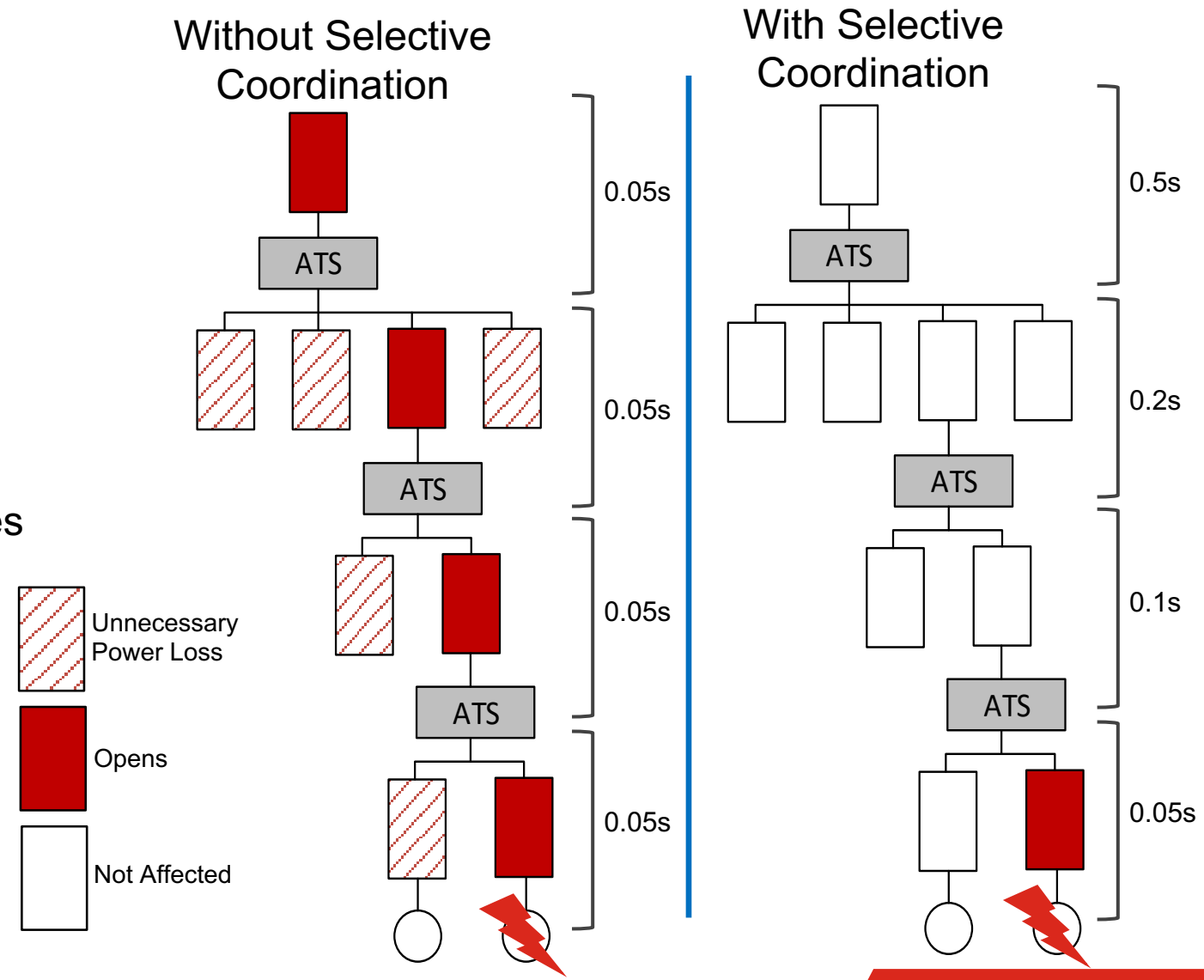
- Typical UL1066 LSIG breaker
- Short-Time pickup and delay:
  - Determines the amount of current the breaker will carry for a short period of time, allowing downstream protective devices to clear short-circuits without tripping the upstream device





Selective Coordination

- Selective coordination is required for emergency, legally required standby and critical operations power systems circuits
- NEC-2020, 700.32, 701.32, and 708.54 "…over-current devices shall be selectively coordinated…"
- Selective coordination is achieved using fuses and circuit breakers, The transfer switches placed in these systems must support selective coordination.



480VAC

Bus 1: AFC: 125,000A

OCPD

Short-Time Current Rating
125,000A. Duration 0.5s

Bus 2: AFC: 85,000A

OCPD

Short-Time Current Rating
85,000A. Duration 0.5s

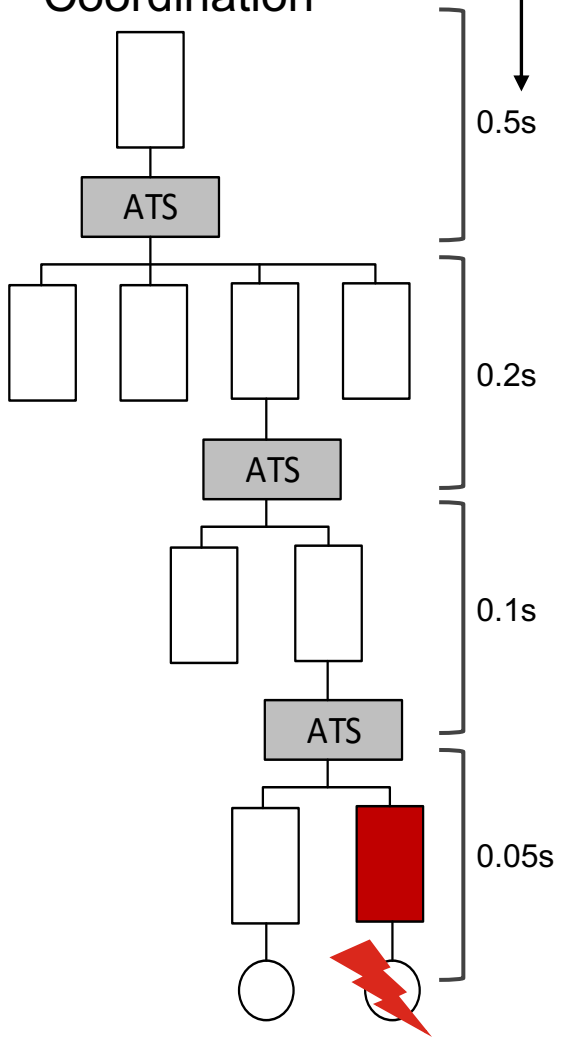
Bus 3: AFC: 65,000A

OCPD

Short-Time Current Rating
65,000A. Duration 0.5s

Breaker
Short-Time Durations

With Selective
Coordination

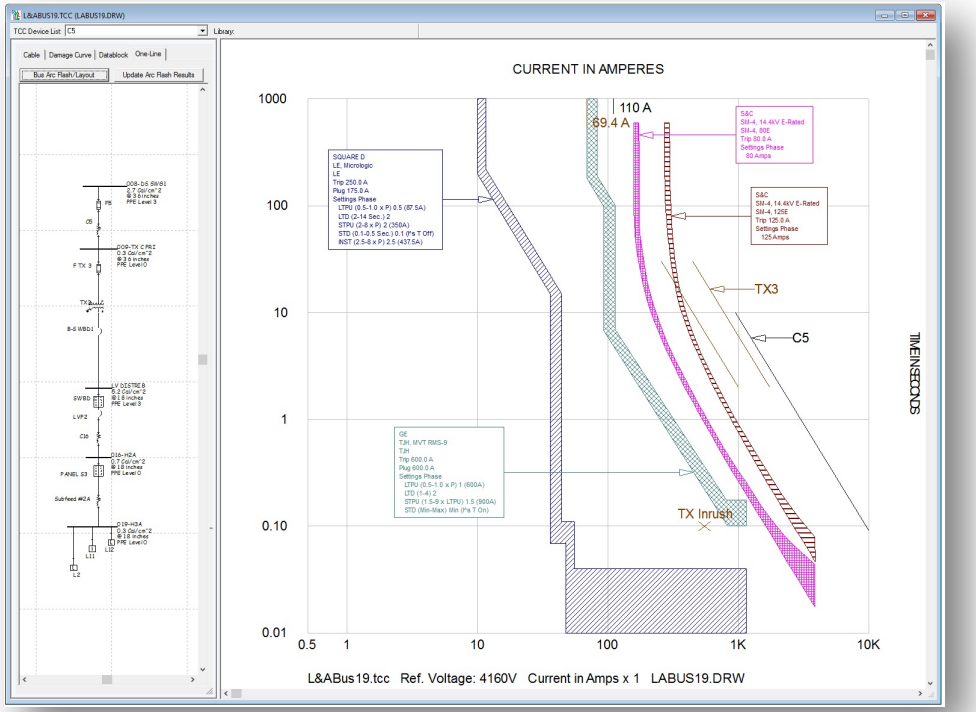


Some Of The Challenges

- Detailed coordination studies haven't been completed
  - Utility transformer hasn't been selected
  - Equipment (transfer switch, conductors, etc.) must be braced for the fault current

High short-time WCR simplifies selective coordination strategies

- Unknown switchboard/switchgear OEMs and breaker selection
- Limited space in the electrical room
  - Transfer switch upsize to meet the short-circuit rating
- New breaker models from the OEMs
  - Transfer switch manufacturers may need to test with new the breakers per UL 1008 7th Edition



LV Switchboards Vs. Switchgear

- **Switchboard**
- UL891
  - Dead-front Switchboard
  - Circuit breakers are typically UL489 MCCB/ICCB
    - Can contain UL-1066 breakers
  - Circuit breakers not required to be in individual compartments
  - Evaluated for short-circuit 0.05s (3 cycles) ONLY and NO short-time test
  - Instantaneous trip-response is required
  - Short-circuit 150KAIC, e.g.
  - Basic office, commercial building, and retail

- **Switchgear**
- UL1558 (IEEE C37.20.1 design & NEMA C37.51 test)
  - Metal-enclosed power circuit breaker switchgear
  - Circuit breakers are UL1066 (LVPCB)
    - No molded case circuit breakers
  - Circuit breakers required to be in separate metal compartments
  - Evaluated for short-circuit 0.067s (4 cycles) and short-time 0.5s (30 cycles)
  - Instantaneous can be turned off
  - Short-circuit 200KAIC, e.g.
  - Healthcare, hospitals

Transfer Switch Application Example 1

- The transfer switch is fed by a UL 1558 switchgear
  - UL-1066 breaker have a short-time trip response
  - The transfer switch must have a short-time rating
  - The short-time response of the circuit breaker must be coordinated with short-time current rating of the transfer switch as listed on the transfer switch nameplate

UL 1558 Switchgear

Breaker has short-time trip response.
AFC: 125,000A

Short-time WCR:
125,000A @600 VAC
for 0.5 seconds

Transfer Switch Application Example 2

- The transfer switch is fed by a UL 891 switchboard
  - UL489 circuit breaker
  - The circuit breaker must include an instantaneous trip response
  - Circuit breaker must trip in 0.05s (3 cycles) or faster

UL 891 Switchboard

Breaker has instantaneous trip response
AFC: 65,000A

Time-Based WCR:
65,000A @600 VAC
for 0.05 seconds (3-Cycles)

AIA MasterSpec® Objective Specification

- Fault-Current Withstand and Closing Ratings (WCR): UL 1008 WCR must be listed as meeting the requirements for use with protective devices at installation locations, under specified fault conditions. WCR shall be based on use of the same set of contacts for the withstand test and the closing test. WCR shall be adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

    - Transfer switches shall have a time-duration Withstand and Closing Rating (WCR) of at least 0.05 seconds (3 cycles at 60 Hz).
    - Short-time WCR shall be rated for a duration of 0.5 seconds (30 cycles at 60 Hz).
    - Transfers switches with Withstand Ratings only and without Closing Rating shall not be acceptable. This applies for Short-time and Time Duration WCR Ratings.

Course Summary

Applying Transfer Switch High WCR & Short-Time Rating To Simplify Electrical System Design

Transfer switches are critical components in the power system and they are tested to meet UL 1008 Standard for Safety - Transfer Switch Equipment. This course discusses some of the UL 1008 testing and passing criteria and then demonstrates that high short-circuit and short-time withstand and closing rating (WCR) help simplify the selection of overcurrent protection devices and enable selective-coordination strategies. This course also touches on switchboards (UL891) and switchgear (UL1558).

Conclusions:

- Transfer switches have short-circuit withstand/closing (WCR) and short-time ratings
- Specifications should require the transfer switch short-circuit WCR be coordinated with the OCPD at the fault current available on the line side of the transfer switch
- Specify time-based short-circuit withstand/closing rating to simplify OCPD selection and coordination
- Specify short-time withstand/closing rating to enable selective-coordination strategies

Additional Resources

Cummins White Papers

- Considerations for Reliable Closed Transition Transfer Switches

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Power Generation

Power topic #5823 | Technical information from Cummins Power Generation

Considerations for reliable closed transition transfer switches

White Paper

By Rich Scroggins, Technical Specialist, Sales Application Engineering

Closed transition transfer switches are becoming more popular for transferring power for life safety and critical processing loads. The benefits are that the emergency power system can be tested without interrupting power to loads and power can be re-transferred to the utility after a failure without interrupting power to loads. There are risks associated with closed transition transfer as two live sources are connected together. This paper reviews best practices for minimizing these risks.

Problems with closed transition transfer originate from a difference in voltage between the two sources at the instant when the two sources are connected. The difference in voltage can be caused by several factors:

- A difference in root mean square (RMS) voltage between the sources.
- A phase angle difference between the two sources
- A transient condition on one of the sources caused by a load switching on or off or instability of one of the sources.

The instantaneous voltage difference between the sources results in a current surge from the source with the higher voltage to the source with the lower voltage at the instant of interconnection of the sources. This current is limited only by the impedance of the sources and the cable or bus connecting the sources. It is this current surge that can result in tripping breakers or, in more extreme cases, damaging equipment.

Our recommendations for minimizing risks of out-of-phase closure include:

- Recognize that all sync check systems allow for sources to be a few degrees out-of-phase at closure resulting in some level of surge current between the sources. Breakers, transfer switches and cable must be sized accordingly.
- Consider active synchronizing with voltage matching to minimize the phase and voltage differences between sources
- Minimize the possibility of transient conditions at the moment of transfer by inhibiting multiple transfer switches from transferring at the same time and preventing other loads from cycling during the transition
- Use a transfer switch "fail to disconnect" or maximum parallel timer relay to shunt-trip an upstream breaker to prevent extended paralleling in the event that a transfer switch fails

Q&A

Please type your questions, comments and feedback in the **Zoom Q&A** window.

PDH certificate, copy of the presentation, and link to the recording will be provided in a follow up email within a 1-2 business days.

Please complete the brief survey upon exiting the webinar!

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Closing

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