PowerHour webinar series for consulting engineers

Experts you trust. Excellence you count on.

Arc Flash and Selective Coordination

Wednesday June 8 1:00 CDT / 2:00 EDT

(1PDH issued by Cummins)

Power Generation

Welcome!

PowerHour is designed to help our engineer partners to…

- Keep up to date on products, technology, and codes and standards development
- Interact with Cummins experts and gain access to ongoing technical support
- Participate at your convenience, live or on-demand
- Earn PDH

Technical tips:

- Audio is available through teleconference, or your computer (don't forget to unmute)
- You are in **"listen only"** mode throughout the event
- Use the **WebEx Q&A Panel** to submit questions, comments, and feedback throughout the event. We will provide sufficient Q&A time after presentation
- If you lose audio, get disconnected, or experience a poor connection, please disconnect and reconnect
- Report technical issues using the **WebEx Q&A Panel**, or email powergenchannel@cummins.com

Meet your panelists

Cummins presenter:

Rich Scroggins

Technical Advisor, Global Application Engineering

Cummins facilitator:

Tom Bakritzes, Global Sales Training Manager

Your local Cummins contacts:

- IL: John Kilinskis, Cummins Sales and Service, Central region
- TX: Scott Thomas, Cummins Sales and Service, Gulf region
- IN, KY, OH, TN, WV: Tom Stadulis, Cummins Sales and Service, East region

Learning Objectives

Participants will be able to:

- Describe NFPA requirements for arc flash incident energy calculation, labeling and PPE so that their designs appropriately address arc flash hazards.
- Define generator control arc flash mitigation capability so that their designs will minimize arc flash hazard
- Describe NFPA 70 and NFPA 99 requirements for Selective Coordination so that they will know what coordination requirement applies to their application.
- Describe challenges and trade offs associated with selective coordination so they can make informed choices about the benefits and risks of selective coordination.

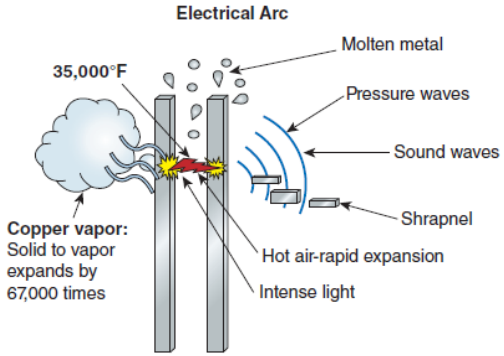
The Challenge

- Arc Flash Incident Energy is directly proportional to arcing time
  - Minimize Arc Flash Hazard by instantaneously interrupting fault current
- Selective coordination isolates faults so that outages are limited to faulted circuits or equipment
  - Coordination is simplified by delayed interruption of fault current

What is Arc Flash?

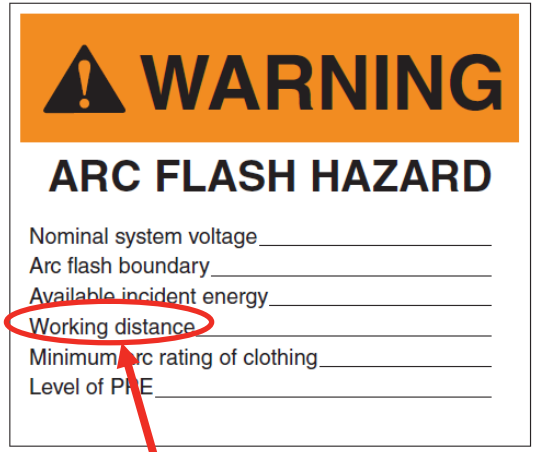
NFPA 70E Definitions

- Arc Flash Hazard – “A dangerous condition associated with the release of energy caused by an electric arc”
- Arc Flash Boundary. “a distance from … which a person could receive a second degree burn”
  - Incident energy = 1.2 cal/cm^2
- Arc Rating – The value attributed to materials that describes their performance to exposure to an electrical arc discharge



NFPA 70E Requirements

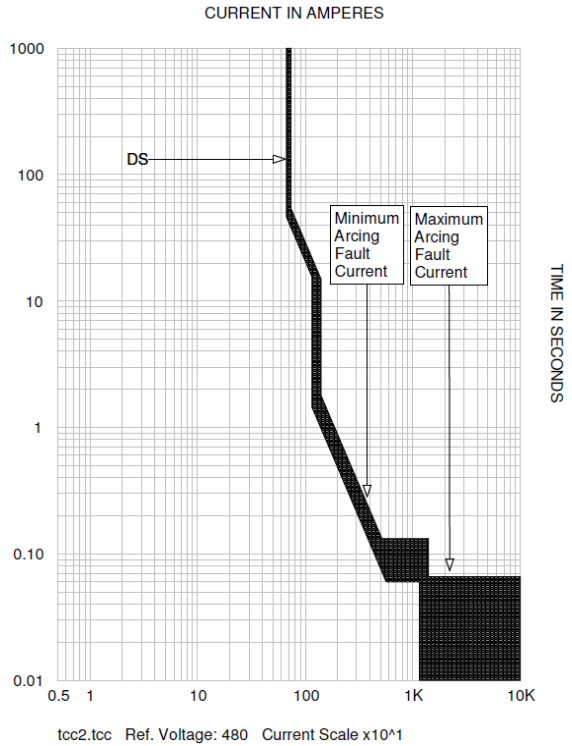
- NFPA 70E requires an energized work permit when a “likelihood of injury from an exposure to an arc flash hazard exists” 130.2(A)(1)(2)
- The work permit shall include the results of an Arc Flash Risk Assessment
- The Arc Flash Risk Assessment shall determine 130.5(1)
  - Appropriate safety related work practices
    - Including Maintenance Switching
  - Arc Flash Boundary
  - PPE to be used within the arc flash boundary
- NEC 110-16 requires equipment to be marked to warn of arc flash hazards



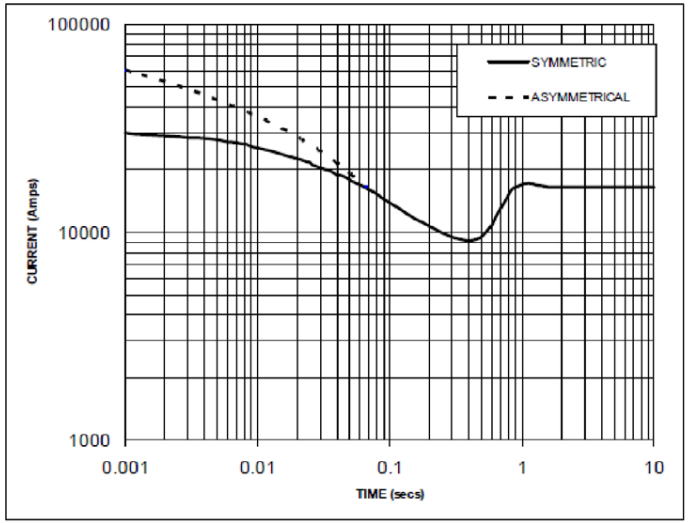
Typically 18” for LV panel boards, 24” for LV switchgear

Arc Flash Incident Energy Calculations

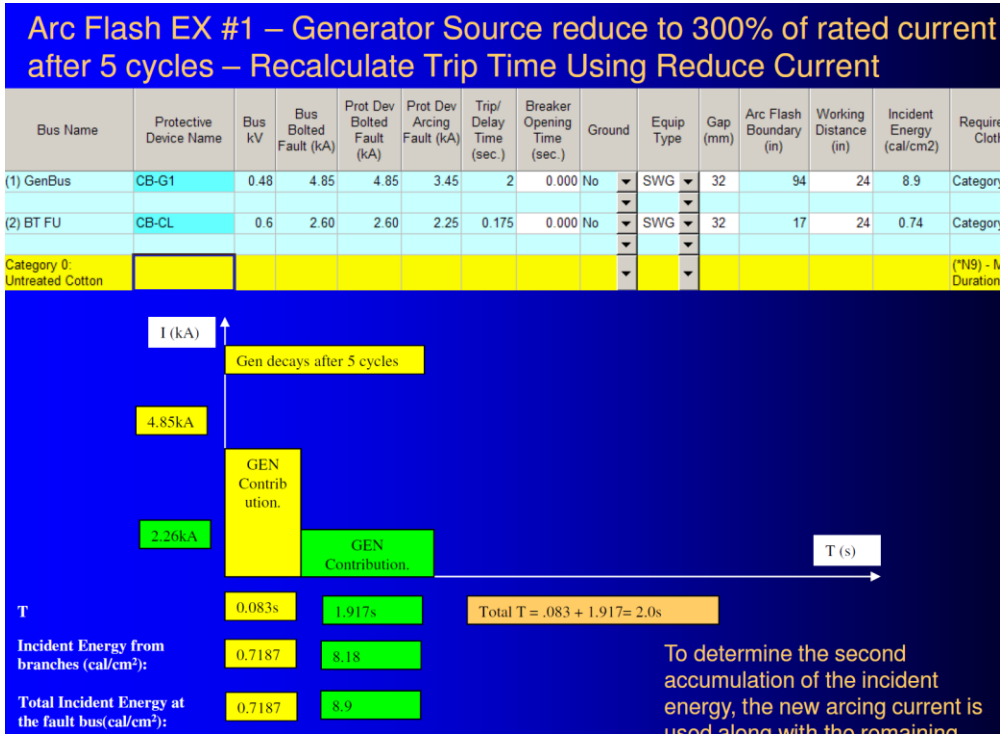
- NFPA 70E refers to IEEE 1584 calculation method for three phase systems from 208 V to 15 kV.
- Arcing current is calculated as a function of bolted fault current
- Incident energy is not necessarily maximum at maximum arcing current
  - Lower arcing current may result in longer fault clearing time
  - Incident energy is directly proportional to arc clearing time
- Incident energy is calculated multiple times
  - Once based on arcing current calculated at maximum available fault current
  - Once based on arcing current at 85% of its maximum value
  - Repeat for each source that may serve the equipment
  - Higher value of incident energy is used



Arc Flash with Decaying Current



Some analysis programs account for decaying generator current in arc flash incident energy calculations



*Reference – **SKM Power Tools**

NFPA 70 240.87 Arc Energy Reduction

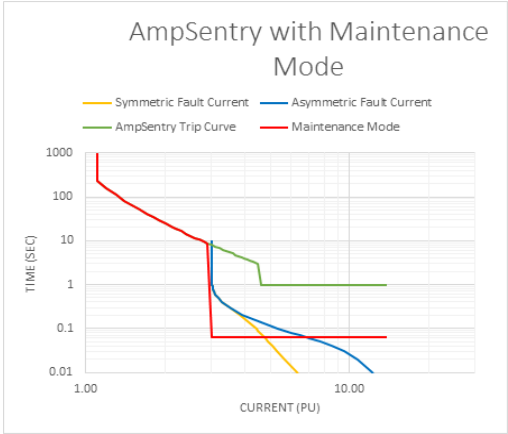
"Where the highest continuous current trip setting is 1200A or higher … one of the following or approved equivalent means (to reduce clearing time) shall be provided…

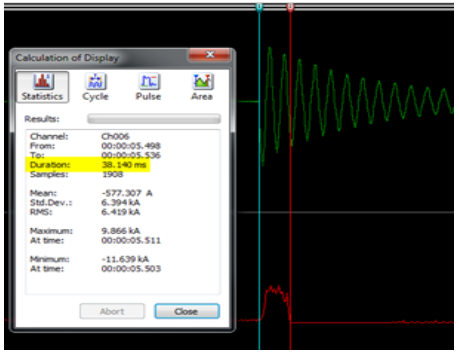
… Energy-reducing maintenance switching

… an energy reducing maintenance switch allows a worker to set a circuit breaker trip time to "no intentional delay"

Maintenance Mode on a generator set

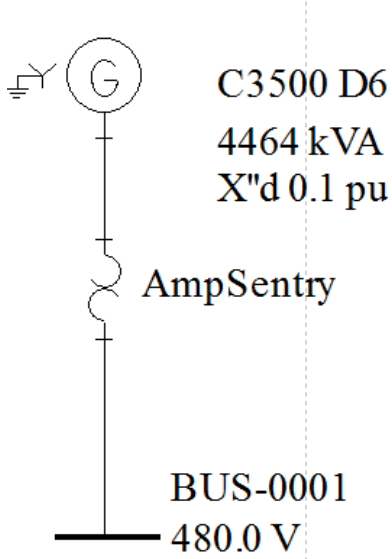
- When maintenance mode is enabled genset will shut down instantaneously in the event of a short circuit, bypassing all time delays
  - Generator shuts down within 50 msec
  - Can also be configured to shunt trip a downstream breaker
- Running the genset in maintenance mode during testing reduces arc flash

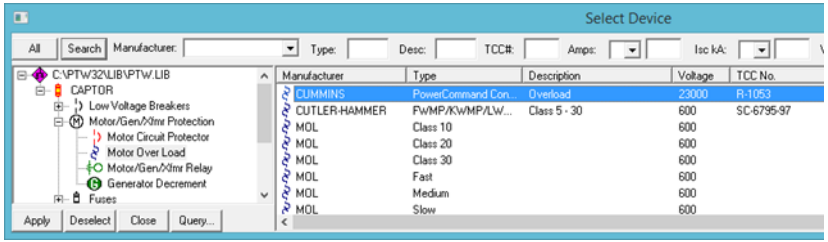


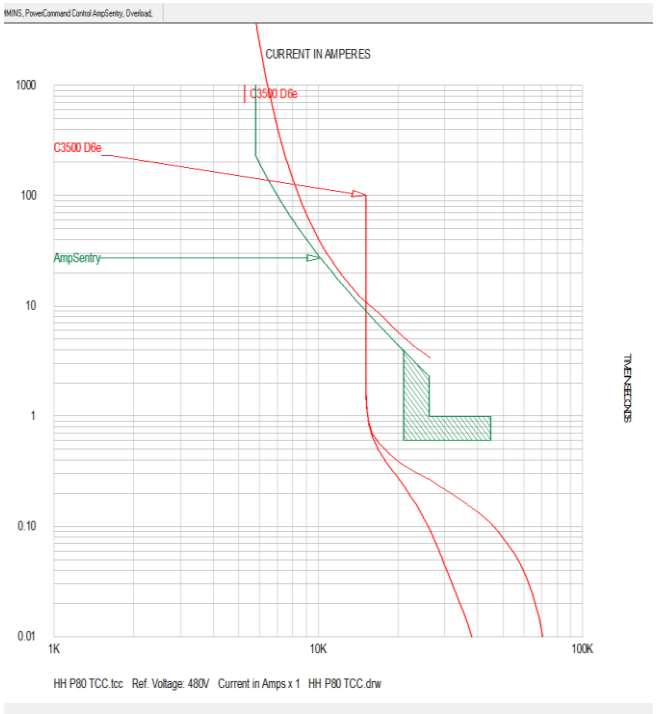


Modeling Arc Flash Incident Energy

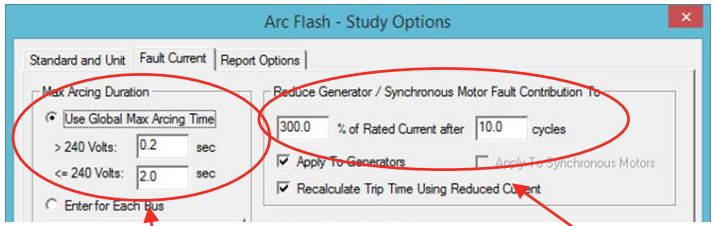
- Cummins PowerCommand AmpSentry is included in SKM as an overload protection device





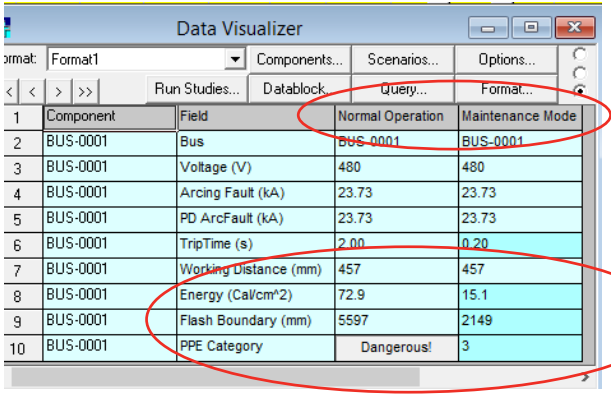


Arc Flash Energy Reduction



- For maintenance mode set Max Arcing Duration to 50 msec + T_d'
  - 50 msec for sensing
  - T_d' for voltage decay
    - Similar to motor contribution

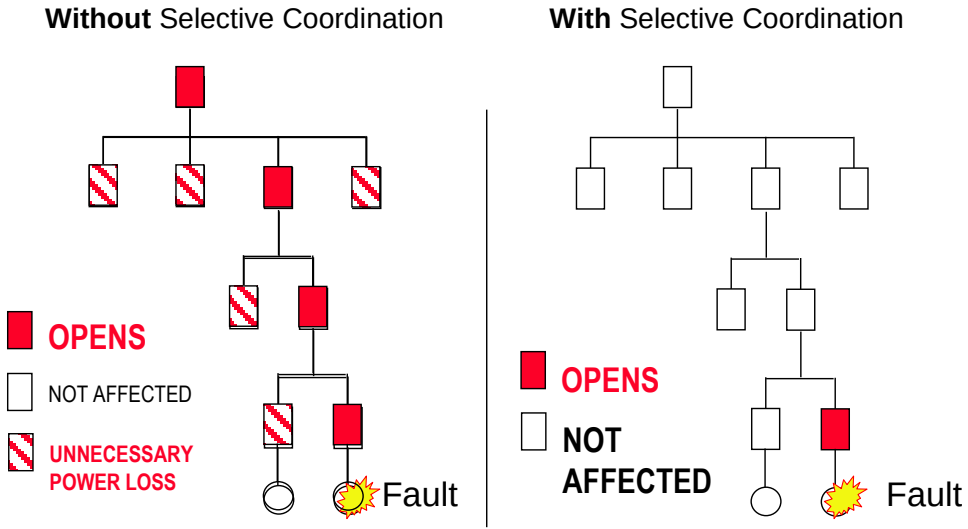
- Reduce generator contribution based on decrement curve
- Set to 300% of rated current after T_d'



	Component	Field	Normal Operation	Maintenance Mode
1				
2	BUS-0001	Bus	BUS-0001	BUS-0001
3	BUS-0001	Voltage (V)	480	480
4	BUS-0001	Arcing Fault (kA)	23.73	23.73
5	BUS-0001	PD ArcFault (kA)	23.73	23.73
6	BUS-0001	TripTime (s)	2.00	0.20
7	BUS-0001	Working Distance (mm)	457	457
8	BUS-0001	Energy (Cal/cm^2)	72.9	15.1
9	BUS-0001	Flash Boundary (mm)	5597	2149
10	BUS-0001	PPE Category	Dangerous!	3

Maintenance Mode results in a substantial reduction in arc flash energy

Selective coordination



NEC Article 100 Definition

- 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…

System Design Tradeoffs

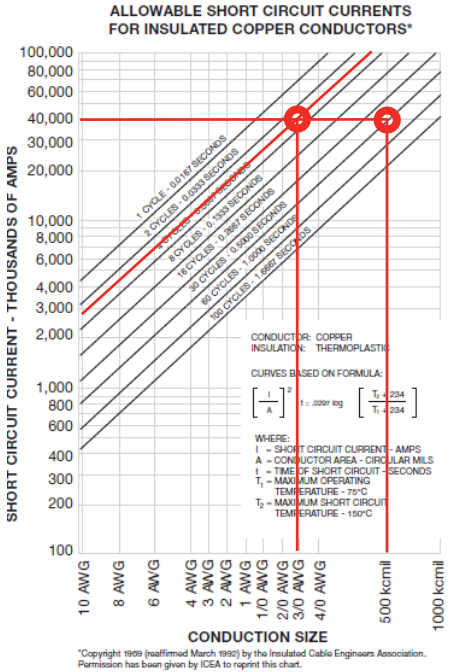
- Coordinated systems present challenges and tradeoffs
  - Fault Isolation
  - System Reliability
  - Equipment Protection
  - Safety
- Downstream equipment is exposed to fault current for a relatively long period of time
  - Is the equipment rated for this? NEC 110-10 violation
  - Increased risk of arc flash
    - Incident energy is directly proportional to fault clearing time

NEC 110-10 Overcurrent protection

- : “The overcurrent protective devices, the total impedence, the component short circuit ratings, and other characteristics of the circuit to be protected shall be selected and coordinated to permit the circuit protective device used to clear a fault to do so without extensive damage to the electrical components of the circuit”.

Cable Protection

- NEC 110-10 requires that cables are sized for short circuit current
- Delayed interruption requires larger cable
- Larger cable results in lower resistance
- Lower resistance results in more arc flash energy downstream



Coordination Studies

- Coordination Studies are based on available fault current in the event of a 3 phase bolted fault
  - A 3 phase bolted fault rarely occurs in practice
  - Delayed interruption results in extremely high arc flash energy
- Single phase arcing ground faults are much more common
  - Lower current levels due to higher resistance in ground path
  - Delayed interruption is manageable

Hazard risk category (HRC)	Clothing description (Typical number of clothing layers given in parentheses)	Minimum arc thermal performance exposure value (ATPV) rating of PPE
1	FR long-sleeve shirt and FR pants or FR coverall plus arc-rated face shield or switching hood (1)	4 cal/cm^2
2	FR long-sleeve shirt and FR pants or FR coverall plus switching hood (or face shield with balaclava) (1 or 2)	8 cal/cm^2
3	FR long-sleeve shirt and FR pants or FR coverall and FR jacket and FR pants or total FR clothing system with hood (2 or 3)	25 cal/cm^2
4	FR long-sleeve shirt and FR pants or FR coverall and FR jacket and FR pants or total FR clothing system with hood (2 or 3)	40 cal/cm^2

Definition of Selective Coordination for Health Care Facilities

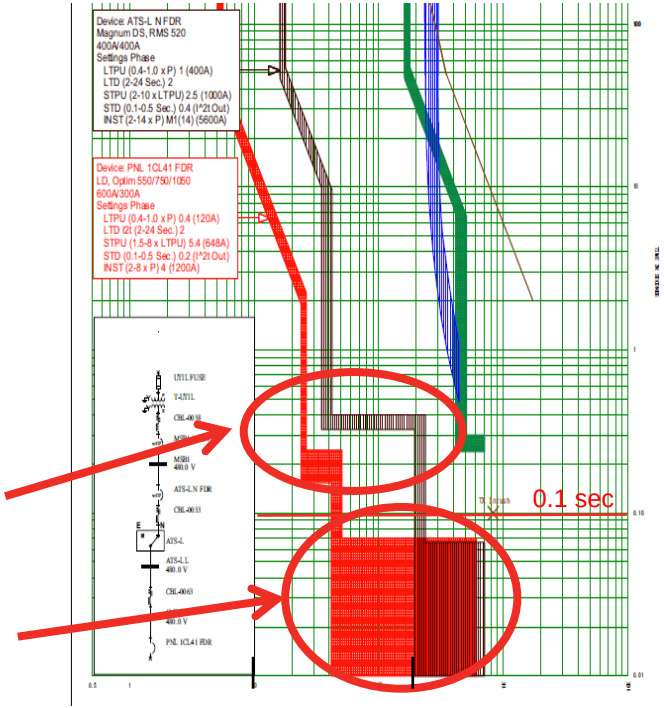
NFPA 99 and NEC 517 do not require coordination in the instantaneous region

"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."

- NFPA 99 6.4.1.2.1
- NEC 517.30 (G)

No overlap for durations longer than 0.1 seconds

Trip curves overlap in the instantaneous region



Selective Coordination in Health Care Facilities

- NFPA 99 Health Care Facilities code requires coordination for the fault's duration beyond 0.1 sec
  - Coordination not required in the instantaneous region of the breaker trip curve
- NFPA 70 definition refers to "full range of overcurrent protective device opening times"
- How does NFPA resolve the apparent conflict?
  - NFPA 70 is an installation standard
  - NFPA 99 is a performance standard
  - Performance is defined as "The manner in which equipment or a system is intended to operate"

Selective Coordination describes system performance so NFPA 99 is the appropriate standard to apply

Selective Coordination in other facilities

- NFPA 110 Standard for Emergency and Standby Power Systems
  - 6.5.1: “The overcurrent devices in the EPSS shall be coordinated to optimize selective tripping of the circuit overcurrent protective devices…”
  - A.6.5.1 “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.”

- Use engineering judgment to minimize risks
  - NFPA 70 700.28 requires that the system is designed and documented by a qualified engineer

    “Selective coordination shall be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems. The selection shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system.”

- Meet the intent of the NEC
  - NFPA 70 90.1(A) “The purpose of this Code is the practical safeguarding of persons and property from hazards arising from the use of electricity”

Conclusions and Recommendations

- Arc flash incident energy is directly proportional to arc clearing time
- Maintenance switching is recognized by the NEC as a means of arc energy reduction
- Delayed interruption of fault current exposes cable, equipment and operators to high levels of energy
- Sizing cable to withstand extended duration fault decreases resistance which increases arc flash energy to downstream equipment
- Balance the risks of temporarily cutting power to the system against safety risks and the risk of permanent system damage due to the increased level of arc flash energy

Q&A

- Type your questions, comments, feedback in the **WebEx Q&A box**. We will get to as many questions as we can
- We will publish consolidated FAQ along with presentation and webinar recording on powersuite.cummins.com

Your local Cummins contacts:

- AZ, ID, NM, NV: Carl Knapp (carl.knapp@cummins.com), Rocky Mountain Region
- CO, MT, ND, UT, WY: Joe Pekarek (joe.a.pekarek@cummins.com), Rocky Mountain Region
- Northern IL, IA: John Kilinskis (john.a.kilinskis@cummins.com), Central Region
- UP of MI, MN, East ND, WI: Michael Munson (michael.s.munson@cummins.com), Central Region
- NB, SD, West MO, KS: Earnest Glaser (earnest.a.glaser@cummins.com), Central Region
- South IL, East MO: Jeff Yates (Jeffery.yates@cummins.com), Central Region
- TX: Scott Thomas (m.scott.thomas@cummins.com), Gulf Region
- FL, GA, SC, NC and Eastern TN: Robert Kelly (robert.kelly@cummins.com), South Region
- NY, NJ, CT, PA, MD: Charles Attisani (charles.attisani@cummins.com): East Region
- CA, HI: Brian E Pumphrey (brian.Pumphrey@cummins.com)
- WA, OR, AK: Tom Tomlinson (tom.tomlinson@cummins.com)
- For other states and territories, email powergenchannel@cummins.com or visit http://power.cummins.com/sales-service-locator

Closing

- Watch out for a follow-up email including
  - A Link to webinar recording and presentation
  - A PDH Certificate
- Visit powersuite.cummins.com for
  - PowerHour webinar recording, presentation and FAQ archive
  - Other Cummins Continuing Education programs
  - Sizing and spec development tool
- Please contact Mohammed Gulam if you have any questions related to the PowerHour webinar (mohammed.gulam@cummins.com)