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Secondary network arc flash case study

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System characteristics

- Utility: Austin Energy
- Location: Austin, TX
- Network size: 3-spot network
- Transformer size: 2000 kVA delta-wye; 7% impedance
- Primary system voltage: 34.5 kV
- Secondary voltage: 480 V
- Network protector size: 3000 A; 480 V
- Network protector type: Eaton CM52
- Available incident energy: approximately 200 cal/cm^2 (without ARMS considered) based on system analysis
- Available fault current on 480 V secondary: 101.2 kA (3 x 33.7 kA for parallel contribution) ①
- CM52 ARMS total clear: 1.9 cycles on average
- CM52 ARMS activation: at 2.5 x 3000 A (nameplate rating) = 7500 A

① Assumes 25 kA symmetrical available fault current on 34.5 kV primary with balanced contribution.

Arc flash event details

Network crews were working in an electrical room tasked to install an 800 A disconnect for a temporary service on the network secondary. The 3-spot network was energized at 480 V on the secondary (34.5 kV on the primary) and all three network protectors were closed and serving load. Each network protector installed was a 3000 A, 480 V Eaton CM52 unit equipped with an Arcflash Reduction Maintenance System™ (ARMS). Prior to performing their work, crews enabled the ARMS function on all three units in the spot. This put all three network protectors in a "hair-trigger" mode, ready to clear any current condition that exceeded 2.5x the nameplate rating.

As part of standard utility work, all procedures were followed in accordance with their specific utility standard practices. The workers had the specified PPE for those specific work conditions. However, as in any work environment, unforeseen events still occur and crews are trained to deal with less than ideal circumstances. During this particular install, the worker lost positive control of the wrench he was using to install 500 kcmil cable to an energized copper bus. This resulted in the wrench hitting the unistrut, which created a path to ground between the unistrut and the live network secondary. The calculated available fault current at the collector bus is 101.2 kA assuming 25 kA symmetrical available fault current on the 34.5 kV primary bus with balanced contribution.

Because the ARMS protection system was enabled as a part of standard working procedure, each CM52 unit interrupted in approximately 1.9 cycles once the 7500 A threshold was met. According to crew reports, the ARMS device activated and cleared the fault before the worker noticed they had made contact with the energized bus. See **Figure 1** for depicition of network arrangement.

This technology has been proven with substantial test data to support its capability; however, this is the first report of the ARMS system being called to action during a network arc flash event involving real world circumstances that prevented severe injury or possible death to the worker. The purpose of this white paper is to share this event with others and help create a safer environment through technology for those working in these applications.

See **Appendix** for additional network protector ARMS technical information.

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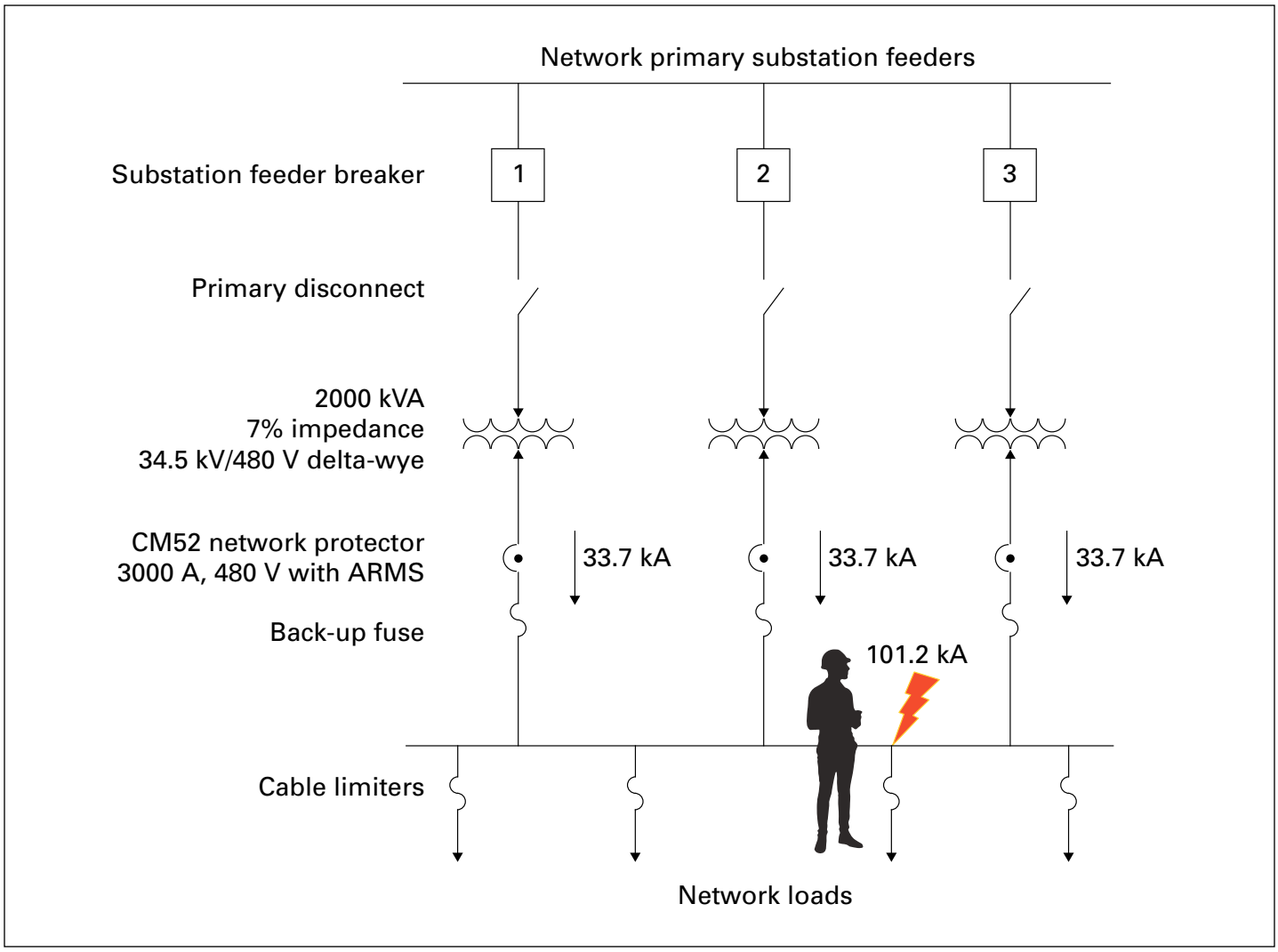

Figure 1. System single-line diagram

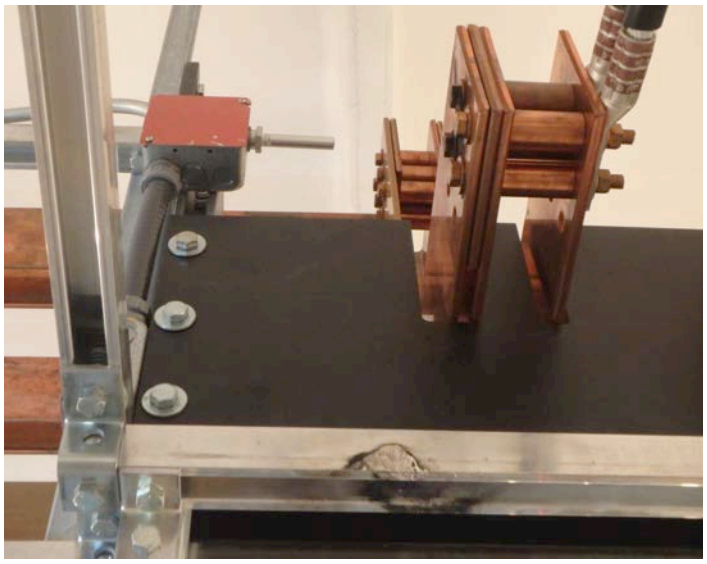

Figure 2. Picture of unistrut where phase-to-ground contact was made

Figure 3. Picture of network secondary bus where work was being installed

Appendix—Eaton Arcflash Reduction Maintenance System

The Arcflash Reduction Maintenance System (ARMS) is an Eaton technology. It was developed for the commercial and industrial market for medium-voltage and low-voltage secondary systems as found with switchgear or any other commercial, utility or industrial applications. Typical utility distribution applications have a point of interconnection that divides where the utility responsibility ends and the utility customer responsibility begins.

The network system is unique. In a network, the utility maintains the secondary grid network and often the spot network. Additionally, network equipment is typically installed in vaults or in other confined-type spaces. The combination of high available fault energy, confined space and a collector that is always energized creates the potential for serious arc flash concerns if the proper protective systems and procedures are not in place.

These concerns are what drove Eaton to adapt this arc flash reduction system to network systems. Arc flash is a significant concern and Eaton has a proven solution to address it.

A network protector equipped with an ARMS unit can improve safety by providing a simple and reliable method to reduce fault clearing time. The ARMS unit uses a separate analog trip circuit that provides faster interruption times than the standard (digital) "instantaneous" protection. Work locations downstream of a network protector with an ARMS unit can have a significantly lower incident energy level.

The ARMS unit can operate without power. During a fault condition, the energy driven by the fault current is enough to power the analog circuit and also initiate the trip. This is a key advantage over other arc flash reduction systems. The ARMS unit is designed to only be turned ON during maintenance; this reduces having nuisance tripping during normal operation. There are some utilities that leave the ARMS unit activated all the time, but this should only be done with very careful consideration as to not impact normal operation. When using the ARMS unit under normal maintenance procedures, ARMS would be activated prior to maintenance. Controllers can turn ON ARMS protection remotely as part of scheduled maintenance procedures before crews even enter the vault.

Here are a few key advantages of the Eaton Network Protector Arcflash Reduction Maintenance System (ARMS):

- The ARMS protective circuit is energy harnessing. For example: Assume maintenance was performed on a spot network and a mistake was made shorting the network secondary to ground. ARMS would clear in the absence of control power.

  Note: In this scenario, the ARMS would have been activated prior to maintenance, therefore the device is active even though the network protector does not have power. When the fault occurs, the ARMS powers up due to the fault current running through the sensor circuit and then trips and locks out the network protector, effectively reducing the fault exposure to 8 or less cal per cm^2 (as tested).

- The ARMS activates sub cycle (4ms) and is set to 2.5x the network protector current rating. The CM52 is the fastest network protector available on the market. The total clear time is determined by the processing speed plus the opening time of the device used to clear the arc flash condition. The CM52 unit total clear time on average was found to be 1.9 cycles. Due to mechanical limitations, other network protector models have not been found to compete with the CM52 interruption speed. This is why the ARMS would not be effective with any other protector type due to the slower total clear time.
- The ARMS does not rely on a microprocessor like a light sensor would, for example. The ARMS is an analog circuit designed for speed, clipping the 1 to 3 cycles from a microprocessor time that other solutions have.
- The ARMS does not need any qualifiers to trip. (Light sensors usually require current qualifiers or they are subject to nuisance tripping due to light sources other than arc flash.)
- The ARMS is self-contained and comes pre-installed on the CM52, so no wiring or labor is required. External activation can be accomplished numerous ways (pendant, SCADA, RAD, etc.).
- The ARMS has been tested in a lab on a spot network to qualify the ratings. The system is applied in network and switchgear applications worldwide. Additional testing on nearly 100 CM52 units was also conducted, proving the interruption time to be consistently between 1.8 to 2.3 cycles with an average of 1.9 cycles.
- The ARMS has built-in communication and works directly with the Eaton VaultGard communications module. It can be activated and monitored remotely.

ARMS graphs

NFPA 70E

Hazard risk category	Clothing description (Typical number of clothing layers in parentheses)	Required minimum arc rating PPE*
0	Non-melting, flammable materials (i.e., untreated cotton, wool, rayon, silk or blends of these materials) with a fabric weight of at least 4.5 oz/yd (1)	N/A
1	FR shirt and FR pants or FR coverall (1)	4
2	Cotton underwear, conventional short sleeve and briefs/shorts plus FR shirt and FR pants (1 or 2)	8
3	Cotton underwear plus FR shirt and FR pants plus FR coverall, or cotton underwear plus two FR coveralls (2 or 3)	25
4	Cotton underwear plus FR shirt and FR pants with full multi-layer flash suit (3 or more)	40

Typical 480 V spot network

*(cal/cm²)

Figure 4. NFPA 70E PPE rating table

Graphic shows the necessary amount of PPE needed at various incident energy points. The ARMS is preset to trip at 2.5 times the breaker element CT rating and can actuate within 0.24 cycles with a total clear average of 1.9 cycles.

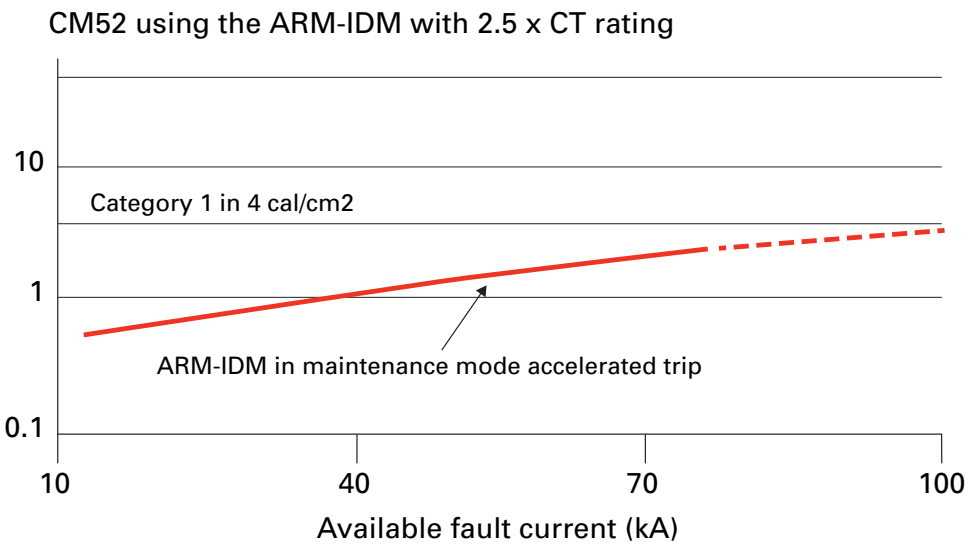

Figure 5. Fault current-time ARMS table

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