ASCO Power Technologies™

NEC® - Specified Methods for Arc Energy Reduction

White Paper

Life Is On | Schneider Electric

NEC® - Specified Methods for Arc Energy Reduction

In the 2017 *National Electrical Code®* (NEC®), Article 240.87 – *Arc Energy Reduction* requires that a method for reducing fault clearing time be provided when equipment is supplied with electricity through overcurrent protection devices rated (or adjustable to) 1200 Amps or higher. To reduce available arc energy, many electrical equipment manufacturers offer Energy-Reducing Maintenance Switches (ERMS), which is one of the NEC-approved methods, for use with their equipment. The following narrative describes the approved methods and explains ERMS design and use.

BACKGROUND INFORMATION

Electrical equipment service activities present arc flash risks to workers, which employers must manage in accordance with government regulations and industry codes. Arc flashes result from arcing faults, which occur when dielectric breakdown forms a low-resistance path through substances between two electrical conductors, allowing current to pass through air. When such faults occur, they release energy in the form of heat and pressure, which can injure people and cause property damage. In addition, arc flashes emit radiation and debris that can damage eyes and burn skin. Because arc faults can occur at relatively low current levels, they may not trip overcurrent protection devices.

Government regulations and industry standards address methods for mitigating arc fault risks. In 1970, the United States Congress enacted the Occupational Health and Safety Act. This statute requires that employers provide workplaces that are free of recognized hazards, including electrical hazards. The Act also created the Occupational Health and Safety Administrations (OSHA), which issues workplace safety regulations and enforces their implementation. Electrical safety regulations are found in the US Code of Federal Regulations, including 29 CFR 1910 and 29 CFR 1926, which address safety in workplaces and construction sites.

To assist OSHA in regulating electrical safety, the National Fire Protection Association developed *NFPA 70E: Standard for Electrical Safety in the Workplace*. Compliance requires that a hazard assessment be conducted for arc flash risks at electrical equipment located throughout workplaces. Both NFPA 70E and *IEEE 1584-2002 - Guide for Performing Arc Flash Hazard Calculations* provide methods for performing the necessary assessments. Addition detail can be found in our prior white paper entitled Arc Flash Studies and Transfer Switch Serviceability.

OPTIONS FOR REDUCING ARC ENERGY

Equipment installation practices are specified by the NEC. When overcurrent protection devices are rated or adjustable to 1200 Amps or more, NEC Article 240.87 requires that a method for reducing available arc energy be provided. The standard provides the following options:

1. Zone-selective interlocking
2. Differential relaying
3. Energy-reducing maintenance switching with local status indicator
4. Energy-reducing active arc flash mitigation system
5. An instantaneous trip setting that is less than the available arcing current
6. An instantaneous override that is less than the available arcing current
7. An approved equivalent means

Notably, the NEC does not state a performance or testing requirement for the listed methods. Each option is summarized as follows.

Zone-Selective Interlocking

Understanding *Zone-Selective Interlocking* (ZSI) also requires an understanding of *selective coordination* of overcurrent protection devices in electrical power distribution systems. In selectively coordinated systems, upstream circuit breakers use longer preset trip intervals and downstream units are set to trip more quickly. This arrangement causes the breaker located closest to the fault to open, thus minimizing the amount of equipment that is depowered. Figures 1A and 1B compare an uncoordinated system to a selectively coordinated system. For additional information, review our white paper entitled Selective Coordination Basics.

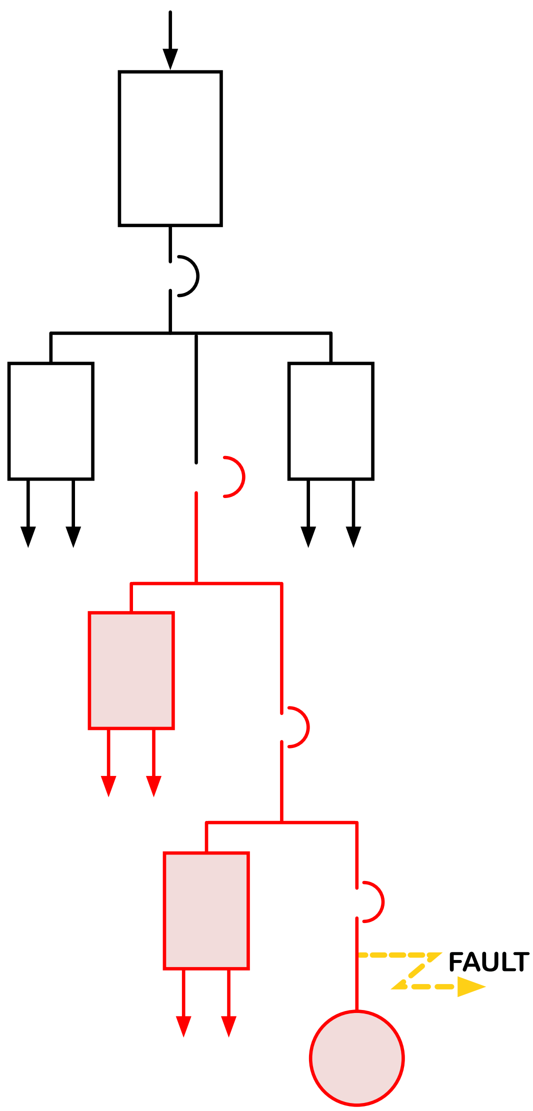

Figure 1A: In an uncoordinated system, a fault could open any upstream breaker and isolate an unnecessary quantity of loads.

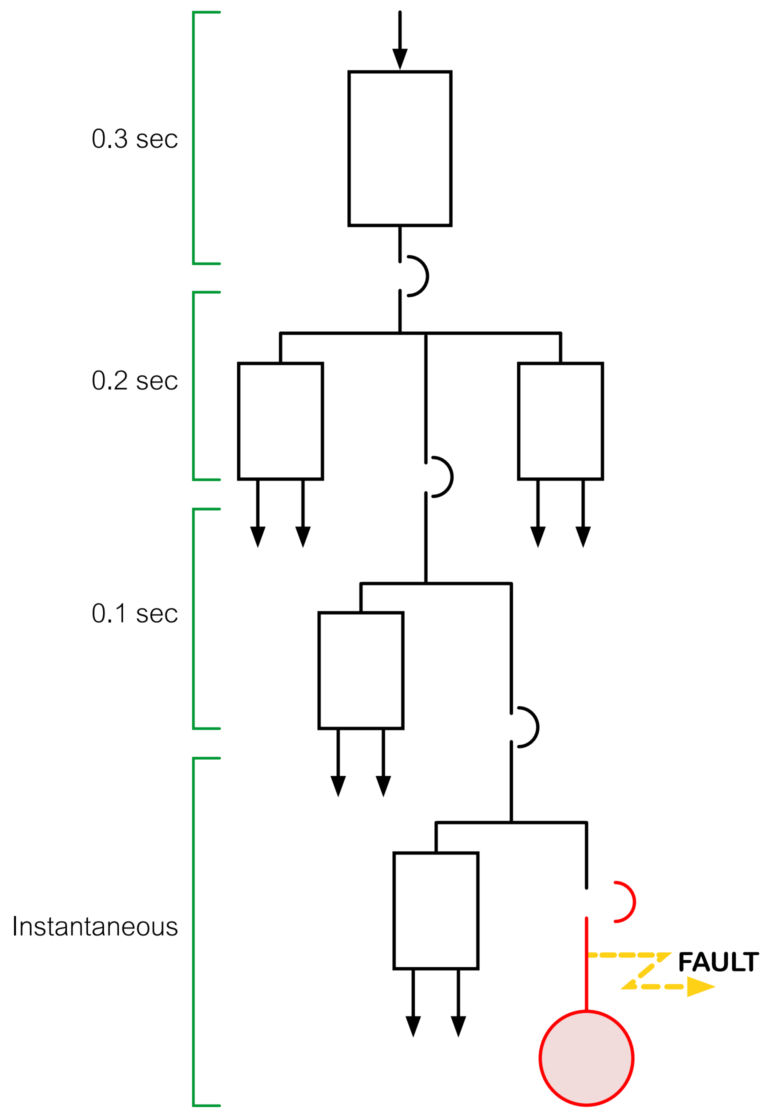

Figure 1B: A selectively coordinated system opens the breaker closest to a fault, minimizing operational disruption.

When a downstream fault occurs in a selectively coordinated system, upstream devices must tolerate the fault current until the fault is cleared by a downstream breaker. Any tripping delay subjects the affected portions of the system to electrical stress. During this time, people working on equipment along the fault path remain exposed to arc flash risks until any trip delays expire and the fault is cleared. ZSI limits the associated fault stress on the systems and the incident energy near workers by reducing the time required to trip the upstream breaker, and preserves coordination between overcurrent protection devices.

Zone-Selective Interlocking is accomplished by establishing a signal circuit between the trip units of upstream and downstream circuit breakers. In this arrangement, the breaker closest to the fault location clears the fault immediately, and simultaneously sends a trip delay signal to the next upstream breaker, as shown in Figure 2A. As with selective coordination, this limits the amount of equipment taken off-line. However, if a fault occurs between the two breaker locations, the upstream breaker does not receive a delay signal, and thus clears the fault immediately (as shown in Figure 2B). This reduces stress on the equipment along the fault path. It also reduces the available incident energy and thus reduces the associated arcing risks.

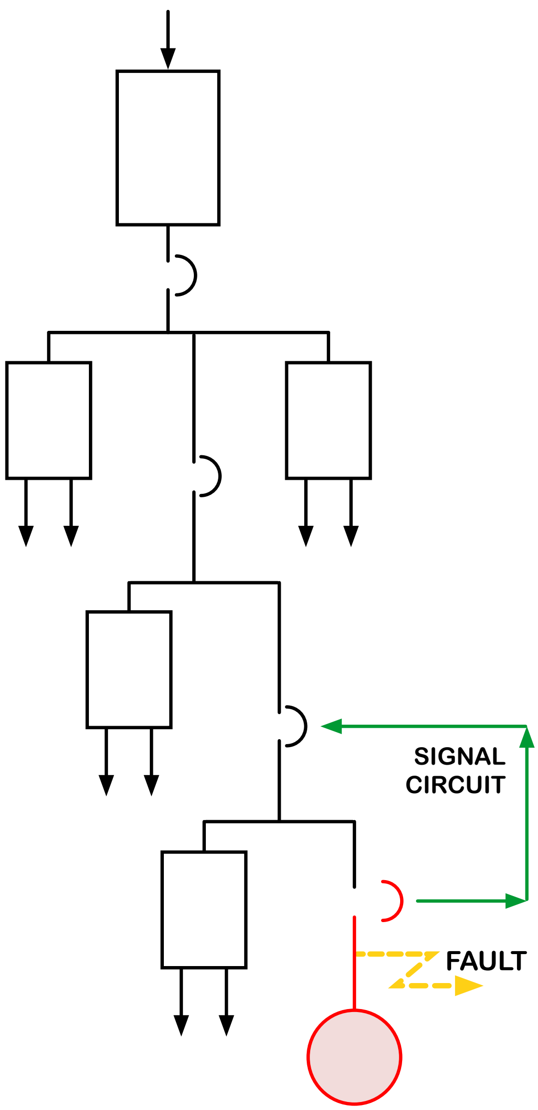

Figure 2A: With ZSI, a downstream fault is detected by the closest breaker, which clears the fault and signals the upstream breaker to invoke a trip delay to keep equipment online.

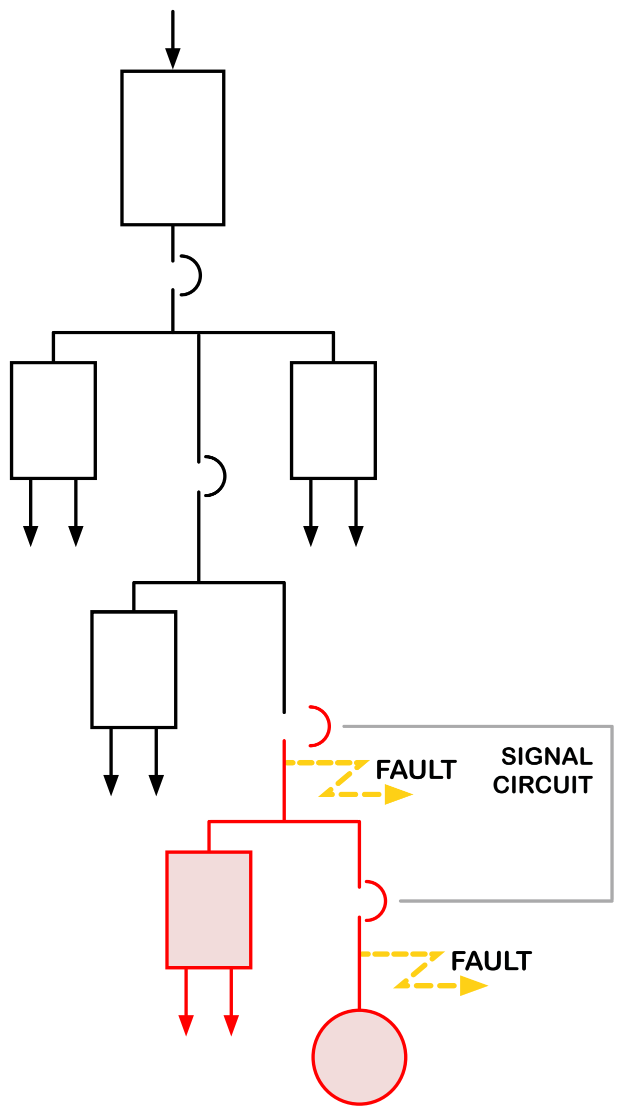

Figure 2B: With ZSI, an upstream fault is cleared by the closest breaker when no signal is received from a downstream breaker. The upstream breaker immediately opens to disconnect downstream equipment.

Zone-Selective Interlocking is available for low voltage and medium voltage applications. It automatically provides arc risk reduction without operator intervention. It may not be compatible with all types of breakers, and requires use of electronic trip units or external protective relays.

Differential Relaying

Incident energy can be managed by using differential relays. In this solution, current transformers are placed upstream and downstream of a zone of protected equipment and connected to a differential relay. If the relay detects that the amount of current exiting the zone does not match the amount of current entering the zone, such as when faults occur in the protected zone, the relay signals the upstream breaker to open. A simplified differential relay scheme is shown in Figure 3.

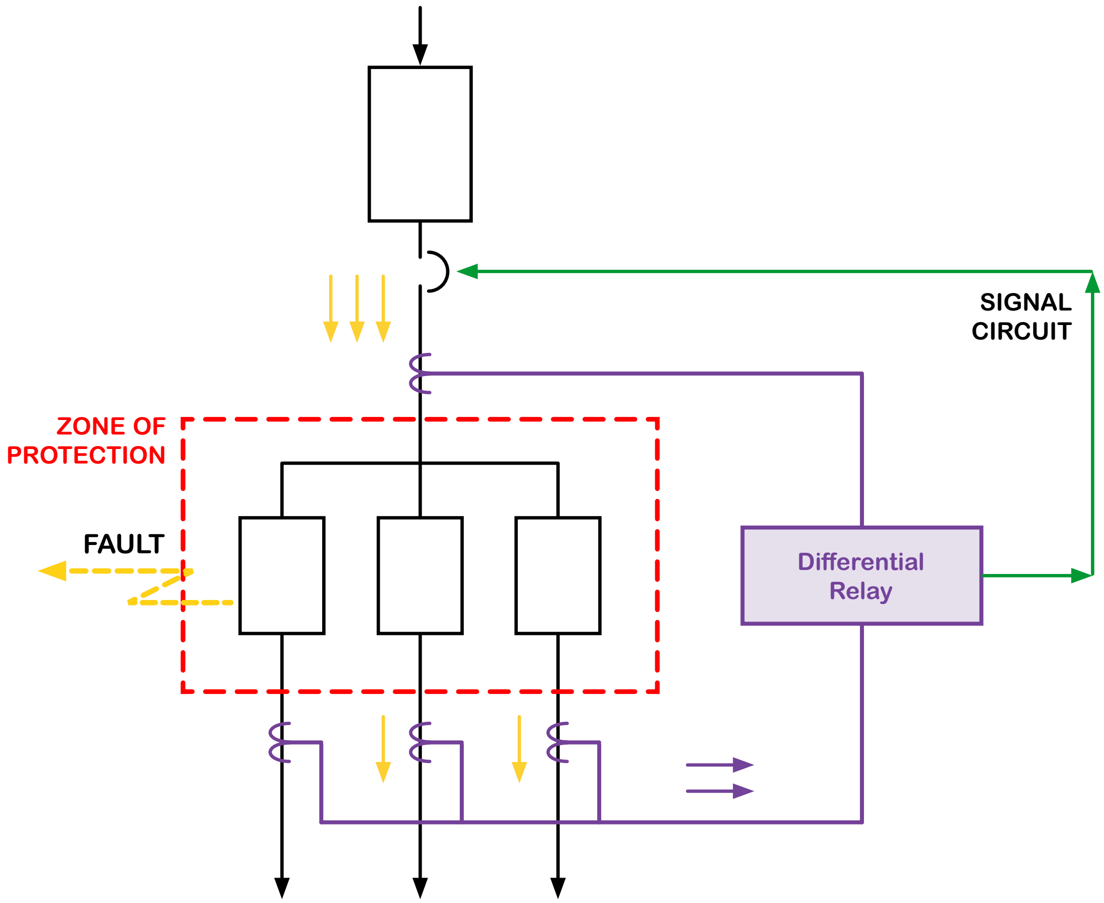

Figure 3: If a differential relay detects a difference between power entering and exiting a zone of protected equipment, it will signal an upstream breaker to open, thus limiting available arc flash energy.

With careful design, differential relay arrangements are immune to inrush currents and pass-through faults, and clear faults without affecting selective coordination of overcurrent protection devices. Due to selective coordination concerns as well as space requirements and cost, differential relaying is more likely to be used in medium voltage applications.

Energy-Reducing Active Arc Flash Mitigation System

By monitoring equipment for the occurrence of arc flash, upstream breakers can be opened quickly when arc flashes occur. This can be implemented by connecting a fast relay to the trip unit of an upstream breaker. When a device such as an overcurrent sensor or optical sensor detects the onset of an arc flash, a relay signals a trip unit to open a circuit breaker instantaneously, limiting available incident energy.

Instantaneous Trip and Override

Circuit breakers are commonly equipped with instantaneous trip and instantaneous override features. An *Instantaneous Trip* setting enables a breaker to open instantly when a specified overcurrent occurs, limiting incident energy. An Instantaneous Override is a setting above which an open breaker will be prevented from closing on a circuit in an overcurrent state. When the value of either or both features is less that the value of arcing current, the arc energy reduction requirements of NEC Article 240.87 are satisfied.

Energy-Reducing Maintenance Switch

An ERMS is simply a switching device that is used to temporarily reduce the trip setting of an upstream circuit breaker. By opening the breaker more quickly when faults occur, incident energy at the equipment is reduced, which in turn reduces the risk of arc flash. By activating the switch before equipment is serviced, available arc energy is reduced.

An ERMS is easy to incorporate into new equipment at reasonable cost, and may protect equipment beyond any downstream breaker. The efficacy of adding it to existing equipment is dependent upon the equipment configuration, and the compatibility of any upstream trip unit and breaker. However, an ERMS is manually operated, not automatic. Failure to activate it results in unmitigated arc flash risks. Failure to deactivate it following service can negate selective coordination arrangements in downstream equipment.

Other Approved Equivalent Means

NEC Article 240.87 allows for the use of an equivalent means for reducing arc energy if approved by the Authority Having Jurisdiction. While this allows designers to arrange custom measures for reducing incident energy, the scope of such measures is beyond the technical purview of this document.

ERMS CONSIDERATIONS

An ERMS can provide an acceptable, low cost and easy-to-install solution for complying with NEC Article 240.87. Nevertheless, it would be incorrect to assume that all breakers above 1200 Amps require an ERMS. An arc energy reduction strategy is commonly the purview of the electrical systems designer. In the absence of indications regarding the provision of an ERMS, the project specification or power system designer should be consulted.

Furthermore, ERMS deployment must be considered in the context of larger selective coordination schemes. Activating ERMS to service upstream equipment may negate selective coordination provisions at downstream equipment, and could result in removing power from more equipment than anticipated if a fault occurs during the service event. While this outcome may be acceptable in some applications, several NEC provisions may require selective coordination in specific life-safety and critical applications.

SUMMARY

The Article 240.87 of the 2017 NEC requires that a method for reducing fault clearing time be provided when overcurrent protection devices are rated or set to 1200 Amps or higher. The Article specifies multiple means for reducing arcing energy to mitigate arc flash risks, including the ERMS described herein. Each of the methods can be used to comply with the NEC requirement. Nevertheless, an ERMS should be selected only when identified in a project specification or after the arc energy strategy for a power distribution system is understood. When the selected strategy is unclear, the necessity for an ERMS or other arc energy reduction measure should be reviewed with the designer of the system or other qualified professional.

REFERENCES

National Fire Protection Association. NFPA 70 - National Electrical Code®, Fourteenth Edition. Quincy, Massachusetts, 2016.

National Fire Protection Association. NFPA 70E - Standard for Electrical Safety in the Workplace. 2018 Edition. Quincy, Massachusetts, 2017.

Institute of Electrical and Electronic Engineers. IEEE 1584 - Guide for Performing Arc Flash Hazard Calculations. Piscataway, New Jersey, 2002.

ASCO Power Technologies, Inc. Arc Flash Studies and Transfer Switch Serviceability. Florham Park, New Jersey. 2017.

ASCO Power Technologies, Inc. Selective Coordination Basics. Florham Park, New Jersey. 2018.

Schneider Electric USA. Arc Flash Reduction Systems - Are They Always a Good Idea? Cedar Rapids, Iowa. 2009.

Life Is On | Schneider Electric

ASCO Power Technologies - Global Headquarters
160 Park Avenue
Florham Park, NJ 07932
Tel: 800 800 ASCO

whitepapers.ascopower.com
customercare@ascopower.com