White Paper **WP083004EN** Effective December 2013

Leadership in circuit protection

Thomas Domitrovich, Vincent Saporita, and Doug Dillie
Eaton

Overview

Eaton has a heritage of innovation in circuit protection that dates back to 1914, and continues to invest in research and development to bring to bear industry-leading solutions. Today, Eaton is providing an even broader range of circuit protection solutions and expertise that support enhanced safety, reliability, and efficiency.

Circuit protection devices are one of the basic building blocks of power distribution systems, and include both circuit breakers and fuses. Both devices have been used since the early 20th century and continue to be applied today.

Eaton is delivering even broader solutions today that include fuses by Eaton's Bussmann business—providing industry-leading circuit protection to solve critical safety, reliability, and efficiency requirements.

With a comprehensive selection of circuit protection devices, the challenge is to determine which technology will provide the most benefit for specific applications, while meeting applicable building and safety codes.

There are four primary considerations when making this decision:

- Personnel safety
- Equipment protection
- System reliability and uptime
- Overall efficiency

This paper provides an overview of available options for selecting the proper type of circuit protection to meet safety, equipment, and system reliability, as well as efficiency goals.

Personnel safety

Power systems are increasing in both size and complexity to meet application requirements across industries. With larger and more complex power systems, there is an increased potential for personnel injury.

There are three primary personnel safety concerns associated with modern power systems:

- Protecting against ground faults
- Mitigating the risk of arc flash events
- Avoiding injuries to personnel

Protecting against ground faults—ground fault protection

When a person comes in contact with an energized conductor or other electrical components, the current flow through the body is typically less than the current rating of overcurrent protective devices. Ground fault circuit interrupters (GFCIs) are designed to protect personnel from electrocution. GFCIs sense ground fault current leaking through a person's body and open the circuit breaker before the individual is seriously injured.

Fundamentally, GFCIs are selected to avoid personnel injury and to meet NEC® requirements.

Eaton's GFCI product offering includes residential circuit breakers with a 10 kA interrupting rating from 15A to 60A. Commercial and industrial offerings include circuit breakers up to a 22 kA interrupting rating from 15A to 50A.

GFCI Circuit Breaker

Powering Business Worldwide

Mitigating the risk of arc flash events

An arc flash is the result of a rapid release of energy from an arcing fault and involves light, heat, sound, and gases. A high-energy arc flash can result in extensive equipment damage, personnel injury, and death. For those applications where personnel must work on energized equipment, there are a variety of techniques designed to avoid personnel injury and to reduce equipment damage, including zone selective interlocking, arc flash reduction maintenance systems, and current limitation.

Zone selective interlocking

A circuit breaker with zone selective interlocking is designed to reduce fault clearing times if a fault occurs while personnel are working on energized circuits between upstream and downstream circuit breakers (zone of protection). Reduced clearing times dramatically reduce arc flash energy.

Zone selective interlocking involves a communication signal between two or more trip units applied on upstream and downstream pairs of breakers that are already selectively coordinated. During fault conditions, each trip unit that senses the fault sends a restraining signal to upstream units. When the upstream unit recognizes the restraining signal, it will remain closed while the downstream breaker clears the fault. Without the restraining signal, when the fault is between the two units, the upstream trip unit trips without an intentional time delay—reducing the clearing time, minimizing damage at the fault point, and reducing arc flash energy.

Zone selective interlocking is available on most Eaton Series C® and Series G® molded-case circuit breakers equipped with electronic trip units as well as Magnum® and Series NRX™ power / insulated-case circuit breakers.

Arcflash Reduction Maintenance System™

Arcflash Reduction Maintenance System solutions are engineered to provide a simple, reliable method to reduce arcing fault clearing time if an arc occurs while personnel is working on energized circuits. With this system enabled, internal circuit breaker digital logic is bypassed by a faster analog tripping circuit. The reduced clearing time reduces arc energy. Arcflash Reduction Maintenance System solutions provide faster than instantaneous clearing times, tripping the breaker quicker than the "instantaneous" setting. Additionally, Arcflash Reduction Maintenance Systems take zone selective interlocking to the next level.

This technology is optional for most Eaton Series G and Series C molded-case circuit breakers equipped with electronic trip units as well as on Magnum and Series NRX power / insulated-case circuit breakers.

Current limitation

Current limiting overcurrent protective devices can dramatically reduce the amount of arcing fault current and the clearing time in higher-level arcing fault conditions, minimizing damage at the fault point and reducing the arc flash energy. Current limiting fuses and current limiting circuit breakers are available.

Magnum MDSX

Current limiting devices are used in a variety of applications—for increasing short-circuit current ratings of industrial control panels, for obtaining higher short-circuit current ratings on individual components, and for use as a line-side device in a series-rated system.

Current Limiting CUBEFuse, Class CF

Eaton offers a robust line of current limiting fuses, both fusible and non-fusible current limiting circuit breakers, and add-on current limiting modules. Current limiting fuses are available from 1/10 through 6000A at 250V and 600V, with interrupting ratings up to 300 kA. Industrial breakers are available in current limiting versions with interrupting ratings up to 200 kA at 480V without fuses in the same physical size as standard and high interrupting rating circuit breakers. Eaton also manufactures 600 Vac fused and non-fused current limiting circuit breakers with interrupting ratings up to 200 kA.

Current Limiting LOW-PEAK Dual-Element Class RK1

Avoiding injuries to personnel—mitigating injury risk

National Fire Protection Association (NFPA) Standard 70E® identifies safe practices for personnel to follow by reducing exposure to major electrical hazards. The standard has helped to raise awareness of safety-related workplace practices and maintenance requirements.

Basic safety principles involve preventing direct contact with energized equipment and working outside the arc flash boundary. If personnel can avoid contact with energized equipment, there is a reduced likelihood of serious injury. Additionally, performing maintenance and operations tasks outside of the arc flash boundary reduces the likelihood of serious injury due to arc flash.

Further, integrating safety protection into the power system is preferable to later relying on personal protective equipment (PPE) and procedures for shock and arc flash safety. The following Eaton solutions are available for inclusion in your next design.

Remote racking

Increasing the distance between personnel and potential sources of arc flash will enhance safety. The ability to remotely rack a power circuit breaker, a molded-case circuit breaker, or an MCC bucket places personnel beyond the arc flash boundary.

Eaton enables remote racking with drawout molded-case circuit breaker switchboards, drawout molded-case circuit breaker panelboards, FlashGard® motor control centers, and metal-enclosed drawout switchgear.

Finger-safe parts

Reducing or eliminating the possibility of accidental contact with an energized part minimizes the potential of both shock and arc flash. This is accomplished by insulating or guarding, thereby allowing operations or maintenance personnel to perform basic functions without being exposed to energized parts.

Eaton offers a wide variety of solutions that provide additional protection to prevent contact with energized parts. Standard products such as panelboards, switchboards, and motor control centers that include a deadfront or another cover are inherently finger-safe. Other products incorporate finger-safe designs, including drawout MCCB panelboards and switchboards, FlashGard motor control centers, Quick-Spec™ coordination panelboards, compact circuit protector switches, and finger-safe power distribution blocks, fuseblocks, and holders.

Safety communicating solutions

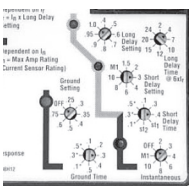
Communications-enabled equipment allows operations and maintenance personnel to perform routine tasks from an external location—without exposure to energized equipment and potential hazards. For example, opening and closing a breaker, data collection, and programming trip units can be accomplished remotely.

Eaton provides a range of power quality and monitoring system solutions that include overcurrent protective devices. Communicating solutions are available on Magnum DS® switchgear, industrial and commercial panelboards and switchboards, and motor control centers equipped with circuit breakers that can communicate.

Equipment protection

Protecting equipment and minimizing damage is crucial to system reliability and impacts the bottom line. Eaton's broad selection of overcurrent protective devices includes basic protective devices as well as more complex devices, which provide additional protection from surges, arcing faults, and ground faults. To help identify the correct overcurrent protection for equipment, consider the following areas of protection.

Ground fault protection



Low-level arcing ground faults typically fall below the current rating of overcurrent protective devices and can cause equipment burn downs. Ground fault protection equipment (GFPE) senses the leakage currents associated with low-level arcing ground faults and causes the overcurrent protective device or the disconnecting means to open—isolating the problem. Sensing and relaying equipment comprise ground fault protection equipment and can be integrated with, or installed separately from, the overcurrent device.

Eaton GFPE solutions include QUICKLAG® circuit breakers, Series C and Series G molded-case circuit breakers and switches, Magnum and Series NRX power and insulated-case circuit breakers, and Pringle® bolted pressure switches.

Arc fault protection

Arcing faults are the cause of many home electrical fires. Implementing arc fault circuit interrupters (AFCIs) helps to mitigate dangerous arcing faults caused by cord, wire, or cable insulation damage.

Eaton AFCI solutions include the CH and BR 15A and 20A residential circuit breakers.

Motor protection

Motor inrush requires the selection of branch circuit overcurrent protective devices that will not open needlessly from normal high inrush currents. At the same time, overcurrent protective devices need to provide a high degree of branch-circuit, short-circuit, and ground-fault protection if a short circuit or a ground fault occurs in the motor branch circuit. To protect the motor, there are overcurrent devices available with adjustable magnetic settings—allowing the operator to set the breaker's magnetic protection level just above the inrush level of the motor. Similarly, time delay fuses are available in many different ampere ratings to allow sizing just above the inrush level of the motor. Both circuit breakers and fuses provide robust short-circuit protection for the motor branch circuit and allow for motor overload protection without causing nuisance operations.

Eaton motor circuit protection solutions include GMCP, HMCP, and HMCPE motor circuit protectors as well as current limiting time-delay fuses.

Conductor protection

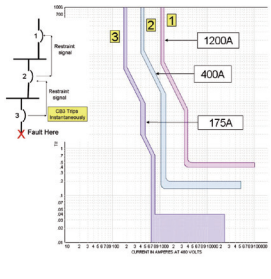
Conductors and cables need to be protected from damaging overloads and short-circuit currents; unprotected conductors can result in violent destruction if a short circuit occurs. Fuses and circuit breakers are tested as per their listing to ensure conductor protection. However, there are special applications where there are no requirements for short-circuit protection, as might be the case on the line side of the service entrance equipment or where taps are used. There are circuit breaker, current-limiting fuse, and cable limiter solutions to provide overcurrent protection where overload and short-circuit protection is required. Additionally, current limiting cable limiters are available where short-circuit protection is desired but not required.

Eaton has a broad range of solutions that includes circuit breakers, current-limiting fuses, and cable limiters that can protect conductors from damage caused by both overloads and short circuits.

System reliability and uptime

Economic, safety, and code compliance factors help to establish the level of reliability required for a power distribution system to support operations and profitability. For example, in banking applications, increased reliability may not be required for safety or code compliance, but it is required to support financial transactions (and profitability). For health care facilities, increased reliability is necessary to meet code requirements as well as patient, personnel, and visitor safety.

Selective coordination



Overcurrent protective devices open a circuit when an overcurrent occurs. To support system reliability and uptime, it is critical that circuit protection devices isolate overcurrent conditions to a single device; this is selective coordination. Essentially, only the device immediately ahead of the overcurrent should open, without additional upstream devices opening at the same time. Selective coordination is determined by the manufacturer-supplied time current characteristic curves in conjunction with selectivity tables and charts for circuit protection devices. Eaton provides a wide selection of both fusible and circuit breaker overcurrent device solutions to meet selective coordination needs/requirements.

Type 2 protection (no damage motor starter protection)

Motor branch circuit faults can cause welded contacts and burnt-open overload relays, resulting in unnecessary downtime. In this situation, the motor starter needs to be repaired or replaced, and the circuit fault must be identified and fixed.

Type 2 protected motor starters can help to enhance the reliability of motor branch circuits. These starters are not damaged from faults in the motor branch circuit and can be returned to service quickly once the fault is cleared. Eaton provides Type 2 tested combinations with HMCP motor circuit protectors and LOW-PEAK dual-element fuses.

Resetting devices

Once an overcurrent device trips, personnel must identify and resolve the situation that caused the overcurrent. Circuit protection devices that can be reset help to reduce downtime. Eaton resettable overcurrent devices include overload relays, motor circuit protectors, molded-case circuit breakers, power circuit breakers, and vacuum interrupters.

Overall efficiency

Effective use of capital includes both upfront and life cycle costs, including maintenance and disposal of equipment. Overcurrent protective devices can help reduce life cycle costs by shortening maintenance time, preventing equipment damage, and minimizing and controlling energy costs.

Lighting control

Lighting is one of the major users of power in commercial facilities. The ability to manage the lighting load enables facility managers to save energy (and cost) over the life of the structure. Eaton molded-case circuit breakers are available with remote open and close capabilities to maximize energy conservation.

Eaton Pow-R-Command™ lighting and load controls turn off the lights when a space is empty and reduces artificial lighting when natural light is abundant.

Effective use of space

Eaton's Integrated Facility Systems™ (IFS™) help to minimize the footprint of electrical distribution equipment. IFS assemblies are unique space-saving structures that combine electrical distribution equipment (found in panelboards and switchboards) with environmental or communications control equipment (commonly grouped and provided in separate enclosures).

Straight rated equipment

Manufacturers need the ability to move machinery, whether it be within the same facility, across town, or across state lines. As a result, one piece of machinery may be called upon to operate in various industrial power system grounding schemes. Slash-rated devices may be inappropriate for some common grounding schemes such as ungrounded, corner grounded, and impedance grounded systems. However, Eaton's line of straight voltage rated fuses and circuit breakers can be used for a range of different power systems, including solidly grounded wye, ungrounded, impedance grounded, and corner grounded delta systems.

Integrated power management

From energy savings to power quality and equipment performance, managing the power in any facility will save money over the life cycle of the structure. By communicating directly with overcurrent devices, energy savings can be achieved through peak demand avoidance, load profile analysis, and power factor monitoring. Overcurrent devices with communications can help identify the source of excess currents, the events that damage equipment or systems, and the equipment that is failing or needs to be replaced—avoiding unplanned downtime and potential safety hazards.

Eaton's broad offering of communicating overcurrent protective devices and accessories provides a way to look at complete systems and identify energy management opportunities, monitor and track energy-saving efforts, and verify how those efforts are impacting energy efficiency.

Conclusion

Knowing how to choose from today's broad selection of overcurrent solutions can help engineers to design power distribution systems that better address important safety, equipment protection, reliability, and efficiency considerations.

Eaton provides the broadest range of fuse and circuit breaker solutions in the industry, so that power system design engineers have the flexibility to design the most effective solution for their application requirements. To learn more about selecting the proper overcurrent device, visit www.eaton.com/consultant.

Eaton
1000 Eaton Boulevard
Cleveland, OH 44122
United States
Eaton.com

Printed in USA
Publication No. WP083004EN / Z14378
December 2013

Powering Business Worldwide