

MAINTENANCE TECHNOLOGY[®]

THE MAGAZINE OF PLANT EQUIPMENT RELIABILITY, MAINTENANCE, AND ASSET MANAGEMENT

THE

FUNDAMENTALS

taking a back-to-basics approach to maintenance...



Increasing Safety And Reliability Using Current Limitation

Current limitation improves safety and reduces downtime.

Dramatic improvements are possible simply by upgrading circuit protection during routine maintenance.

Any maintenance worker will tell you that he/she would rather deal with circuit breakers than fuses. In their view, finding and resetting a breaker is faster than replacing a blown fuse, increasing the time they can devote to more pressing maintenance work.

In reality, current-limiting fuses can actually reduce downtime and increase reliability. For example, a short-circuit that stops one machine can be selectively coordinated so it has no effect on the rest of the plant, and maintenance personnel can concentrate on finding the single fault rather than checking every circuit.

Current-limiting fuses and breakers also improve reliability by limiting the potential energy of an Arc-Flash and increasing short-circuit current ratings (SCCR) of industrial control panels. Electricity can be amazingly destructive, leading to explosion, fire, melted wires and shattered components. If equipment is

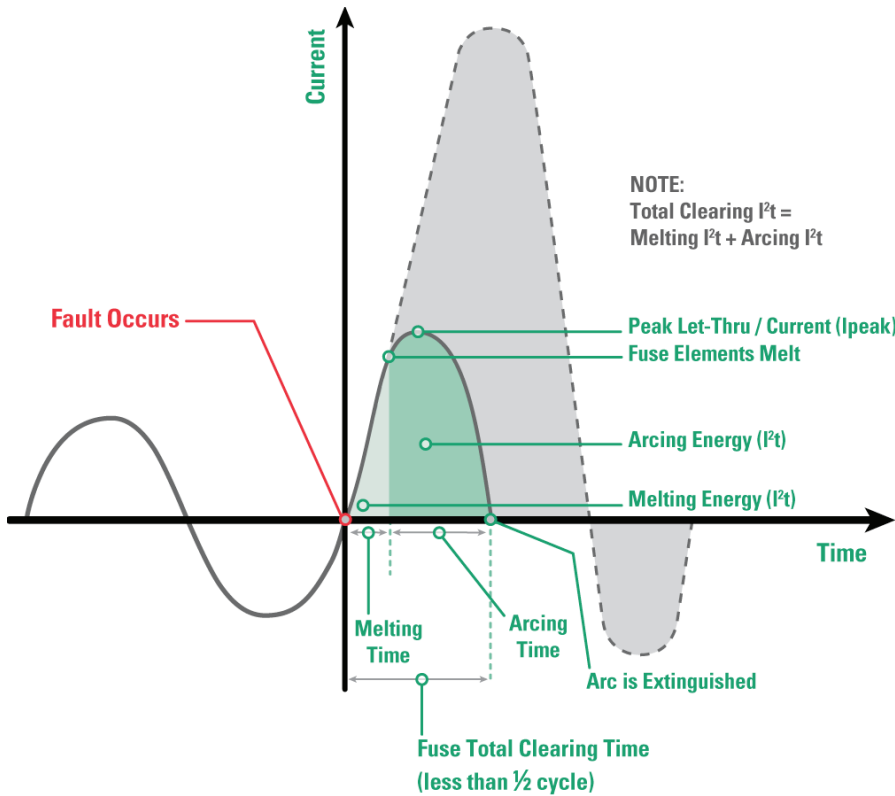


Fig. 1. Current-limiting fuses reduce peak current and clear the circuit in 8.3msec or less, significantly reducing Let-Thru energy in the circuit.

damaged from a destructive fault or Arc-Flash, significant downtime may follow until the equipment is repaired or replaced. Moreover, if there is a serious electrical accident, a manufacturing plant can remain closed for days, or even months, before normal operations can resume.

Current-limiting devices are easily retrofitted into existing electrical systems. The job can be handled as part of normal maintenance or when a fault must be cleared, and it may be as easy as upgrading the fuse. Although current-limiting circuit breakers exist, they are more expensive and not as readily available as the current-limiting fuses on which this article focuses.

Current limitation defined

According to Article 240.2 of the National Electrical Code (NEC), a current-limiting overcurrent protective device reduces the current flowing in a faulted circuit to a level significantly less than the current that could flow if the device were not present. This essentially means that the current-limiting device opens and clears the fault (short-circuit) within the first half cycle of a fault. UL Listed current-limiting fuses must open and clear a fault within 8.3 msec after fault initiation.

The effect of a current-limiting fuse in a circuit is illustrated in Fig. 1. With no current-limiting device in the circuit, the instantaneous peak current during the first half cycle after a fault can be as high as 2.3 times the available rms bolted fault current available at the equipment. For example, if the available rms fault current at an industrial control panel is 100,000 A, the maximum possible instantaneous peak current could be as high as

233,000A. However, with a current-limiting fuse in the circuit, the instantaneous peak current reaches only a small fraction of the maximum possible current at the equipment. A current-limiting fuse not only reduces peak current, it also clears the circuit in 8.3 msec or less.

The area under the curve, or I^2t , is the energy released during a fault. The lower the I^2t , the lower the destructive forces. Therefore, by minimizing both fault duration and energy released, current-limiting fuses greatly minimize Arc-Flash and Arc-Blast hazards. In addition, current-limiting fuses significantly reduce Let-Thru energy in the circuit. (Let-Thru energy produces heating and magnetic effects associated with short circuits.)

UL Listed current-limiting fuses must pass a series of short-circuit tests and limit the I^2t energy to the maximum values shown in Fig. 2. UL class RK1 fuses have much lower I^2t values than UL class RK5. UL class J fuses have even lower maximum values and are sized differently so that they cannot be interchanged with something less current limiting. It is important to note that although these are maximum limits imposed by UL, actual I^2t values and Peak Let-Thru currents are generally much lower and vary from one manufacturer to another.

Selective coordination

Another advantage of current-limiting fuses is that they can provide selective coordination of the electrical system. In a selectively coordinated system, like the simple one illustrated in Fig. 3, only the fuse immediately on the line side of an overcurrent opens, keeping all upstream fuses closed. This makes it relatively easy to find the faulted

UL Current-Limitation Standards

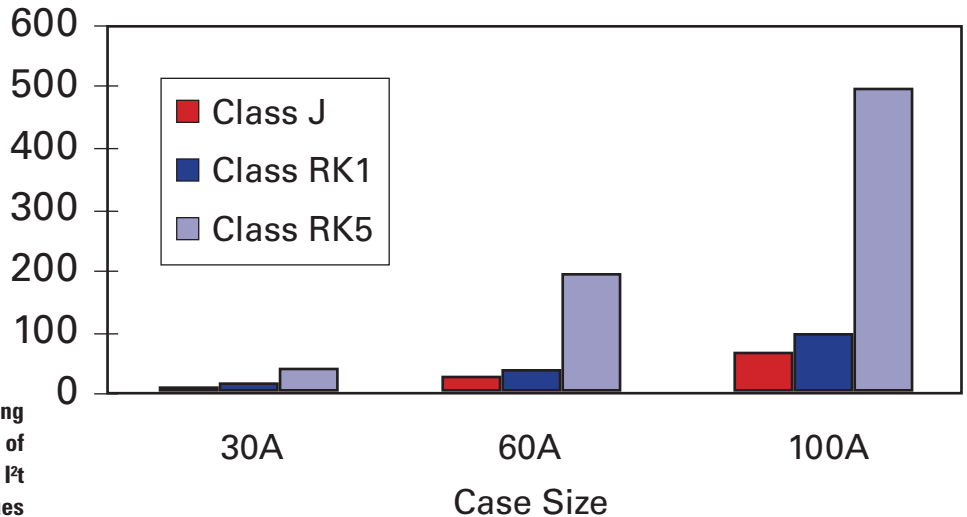


Fig. 2. UL Listed current-limiting fuses must pass a series of short-circuit tests and limit I^2t energy to the maximum values shown here.

circuit so it can be brought back on line quickly. It also helps eliminate blackouts, unplanned work stoppages and safety hazards. With selective coordination, the least amount of I^2t flows to the faulted circuit, reducing Arc-Flash incident energy and PPE required for higher Hazard Risk Categories.

The 2005 NEC requires selectivity coordinated electrical systems for emergency systems (700.27), standby systems (701.18), elevator circuits (620.62) and healthcare facilities (517.26), but selective coordination is best practice for any critical circuit. It is easy to selectively coordinate fuses by maintaining a minimum ratio between the upstream (Line) fuse and downstream (Load) fuse. Circuit breakers can be used in selectively coordinated electrical systems, but coordination is more difficult to achieve, because at high fault current, the breaker trip curves overlap.

Increasing short-circuit current rating

Article 409 of the NEC provides safe installation and construction requirements for industrial control panels for applications such as machine, lighting, conveyor and air-conditioning controls, as well as other panels that control utilization equipment. Article 409.110 requires industrial control panels to be clearly marked with several ratings, including the Short-Circuit Current Rating (SCCR). This is the maximum symmetrical rms current that the device or panel can withstand for a minimum of 3 AC cycles (50 msec) or until a fuse or circuit breaker clears the circuit.

According to UL508A Supplement SB, if a panel contains no current-limiting devices, its SCCR depends on the “weakest” or lowest rated component or combination within the panel. However, Supplement SB also states that if current-limiting fuses are used in the feeder circuit, and if the highest instantaneous current reached during the first half cycle of a fault is less than or equal to the

lowest rated SCCR in any branch circuit, the SCCR of the current-limiting fuse can be applied to the combination.

Supplement SB states that the SCCR of a panel cannot be greater than the interrupting rating of any overcurrent protective device in branch circuits or in the primary of the control circuit. Some manufacturers use fuses or supplementary protectors with low interrupting ratings to protect control circuits. Therefore, simply replacing these devices with current-limiting fuses having higher interrupt ratings can greatly increase the SCCR of many panels. Also, some states or authorities having jurisdiction may allow manufacturers to establish SCCR based on the apparent rms current of the current-limiting fuse.

NEC 110.9 requires overcurrent protective devices and the equipment and wiring they protect to withstand the maximum available fault current to protect workers and equipment from excessive damage if a short circuit occurs. OSHA 1910.132(d) also requires employers to identify electrical hazards in the workplace, inform and train workers on how to avoid the hazards, and provide employees with personal protective equipment.

Therefore, fault current studies must be performed regularly, and the SCCR should be verified to make sure that industrial control panels can survive catastrophic short circuits. This is particularly important when panels are installed, moved or modified, or when Arc-Flash and Electrical Hazard Assessments are performed to meet OSHA and NFPA regulations and standards.

Why SCCR is important

When the SCCR is clearly labeled, installers and inspectors can compare fault current studies at the facility where the panel is to be installed to the SCCR of the control panel to minimize potential hazards. The whole point of overcurrent protection is to prevent electrical components from damage. If the SCCR of an industrial

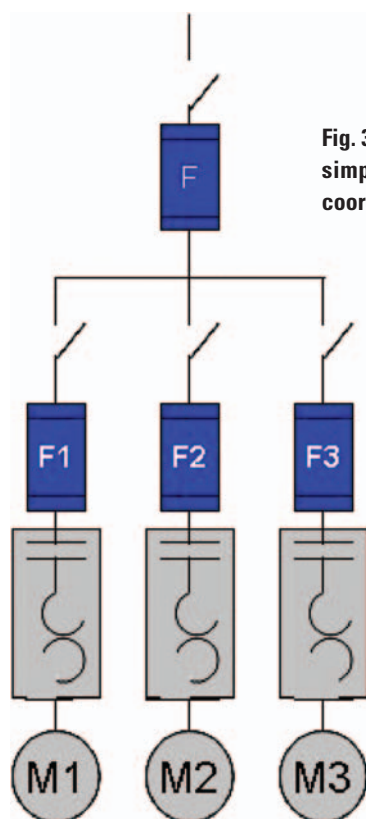


Fig. 3. Diagram of a simple selectively coordinated system

Current-limiting fuses require no maintenance, are fail-safe, and generally limit the destructive energy if an Arc-Flash or short-circuit occurs.

according to IEEE1584, the clearing time for Class RK1 current-limiting fuses actually decreases at higher available fault currents, thus producing lower incident energy at higher fault currents. This is in contrast to electromechanical circuit breakers that reach a fixed minimum opening time as the available fault current increases.

Another important consideration is the fact that low available fault currents (below the current limiting range of the fuse) may produce the greatest hazard. A fuse or circuit breaker takes longer to open at lower fault currents, and a difference of 0.5 sec in clearing time can make a big difference in the amount of Arc-Flash energy produced during an accident. Therefore, when estimating Arc-Flash hazards, consider both maximum and minimum available fault currents.

Conclusion

Current-limiting fuses can be an important addition to plant electrical circuits to reduce downtime, improve reliability and increase safety. Current-limiting fuses require no maintenance, are fail-safe, and generally limit the destructive energy if an Arc-Flash or short-circuit occurs. What's more, these devices can be installed during regular maintenance to improve circuit protection. ❖

Ken Cybart is a senior technical engineer with Littelfuse, Inc., headquartered in Chicago, IL. His 20 years in industry includes teaching and training engineers, managers and electrical workers on safe electrical design, electrical safety, NFPA and OSHA regulations, and working closely with Federal and State OSHA investigators and compliance officers, Underwriters Laboratories and the OSHA National Training Institute. Cybart holds a B.S. in Electrical Engineering from the University of Illinois and is a member of NFPA, NEMA and IEEE. E-mail: KCybart@Littelfuse.com

panel is too low, then the reliability of its components is in jeopardy. What's more, it means worse injuries if there is an electrical accident.

Reducing Arc-Flash incident energy

Reliability extends beyond machinery and equipment to include a reliable electrical supply. The electrical system needs protection against overcurrents, of course, but also against Arc-Flash hazards—a particularly destructive event that is a leading cause of workplace fatalities among qualified electrical workers. According to IEEE and NFPA, a critical factor in controlling the level of possible Arc-Flash energy is the clearing time of an overcurrent protective device. Most standard non-current-limiting circuit breakers can take up to 6 AC cycles (0.1 sec) to open under short circuit conditions. Although this is relatively fast, it is at least 12 times longer than a typical current-limiting fuse, and can expose a worker to a potential Arc-Flash hazard for a longer period of time.

Fuses generally open much quicker than circuit breakers. By opening faster, fuses reduce the fault current and in turn limit the Arc-Flash hazard. In addition,

Reprinted with permission from The Fundamentals, a supplement to Maintenance Technology Magazine, January 2008.

© APPLIED TECHNOLOGY. All Rights Reserved.

Don't take any chances when it comes to Arc-Flash and Electrical Safety. Contact the safety experts at Littelfuse today!

www.littelfuse.com | 800-TEC-FUSE



Expertise Applied | Answers Delivered