Addressing Electrical Safety: Codes and Standards Provide Critical Guidance

Hazards are ever-present in the steel plant environment, and a heightened awareness and emphasis on safety is a necessary priority for our industry. This monthly column, coordinated by members of the AIST Safety & Health Technology Committee, focuses on procedures and practices to promote a safe working environment for everyone.


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Comments are welcome. If you have questions about this topic or other safety issues, please contact safetyfirst@aist.org. Please include your full name, company name, mailing address and email in all correspondence.

There are many hazards in steel production. Many of the procedures advancing workplace safety are well recognized and aligned with the steelmaking process. Yet, electrical shock and arc flash are some of the greatest dangers but are often overlooked.

Perhaps this oversight is because incidents involving employees working on or near energized electrical equipment are infrequent. Regardless, electrical safety incidents typically come at a disproportionate cost to the business and affected individuals. For instance, a utility with electrical systems similar to an integrated steel mill reported that electrical injuries represented less than 2% of all workplace incidents, but these instances accounted for 28 to 52% of injury costs. In the U.S., five to 10 arc flash incidents occur every day, and the average direct costs of an incident start at about US$80,000 and can balloon into the millions of dollars when indirect costs are considered.[1]

It is important to understand the regulations, codes and standards addressing electrical hazards. Every organization needs to establish workplace procedures to help enhance safety — protecting people foremost, as well as the processes and equipment.

In this article, the authors will address the fundamental considerations regarding electrical safety in the workplace, focusing on the codes, standards and technologies advancing arc flash safety.

What Are the Top Electrical Workplace Safety Hazards in Steelmaking?

Arc flash events are the most significant electrical hazard; these are initiated when an electrical arc is sustained due to contact between two energized conductors. Similar to the function of an arc welder, an arc can be sustained on systems 208 V and greater from either a phase-to-ground or phase-to-phase fault. Arc flash events are typically caused while workers are performing troubleshooting or maintenance on energized systems and could be initiated by something as seemingly innocuous as dropping a tool.

Although industry codes and regulations recommend the electrical system be de-energized prior to performing work, some processes in steelmaking — such as drives systems for the continuous caster or rolling mill — make shutting systems down prior to troubleshooting difficult at best.

Whenever a piece of electrical equipment changes state, such as when a breaker is closed, a motor is started or equipment is re-energized after maintenance, there is a risk for an arc flash event. Even equipment that is operating in a steady-state condition has some risk. For example, normal vibrations from energized equipment can cause tools or bolts that were accidentally left inside after a maintenance activity to move and fall across current-carrying conductors — potentially causing an arc flash event. As equipment warms up and cools down, over time the bolted electrical connections can loosen and eventually start arcing.

Industry standards exist today that outline methods to perform an electrical systems study across an industrial facility to calculate the incident or heat energy that a worker will be exposed to should an arc flash event occur at any given electrical panel in the system. After the heat energy is calculated, appropriate fire-rated personal protective equipment (PPE) clothing is required for employees performing energized work from the calculated arc flash heat energy in the specific panel.

Arc flash events do not occur spontaneously in electrical equipment. They result from factors that can, for the most part, be controlled — correct installation, controlled environment, regular maintenance, proper maintenance practices, and protecting electrical equipment from foreign matter such as conductive dust, moisture and rodents. Arc flash remains a concern in the steel industry and enhancing safety in the workplace continues to be a critical priority.

What Are the Current Industry Regulations, Codes and Standards That Focus on Arc Flash?

It's important to understand the difference between regulations (prevailing law) versus codes and standards (recommendations and best practices) in establishing a safe electrical work environment. Regulations are mandated by the prevailing in-country government based on the mill location. Most countries' regulations include language that requires every employer to keep their workers safe.

In the U.S., the government's Occupational Safety and Health Administration (OSHA) regulates safety in steel mills. Historically, the OSHA General Duty Clause covered the overarching requirement to keep employees safe. More recently, regulations are being updated to include additional details focused specifically on electrical workplace safety. For instance, a recent update to OSHA regulations[2] states that, "For each employee exposed to hazards from electric arcs, the employer shall make a reasonable estimate of the incident heat energy to which the employee would be exposed." This language suggests that every industrial facility is required to perform a systems study to determine the heat energy from a potential arc flash.

One of the most relevant standards focused on arc flash safety is the IEEE 1584.[3] This standard, "Guide for Performing Arc Flash Calculations," was first published in 2002. An updated Second Edition was published in December 2018. This standard is the most widely accepted across the global industry. Laboratory tests of arc flash events with the resulting heat energy were recorded to develop a model and a set of equations to calculate the heat energy from an arc flash event. The 2018 Second Edition is supported by nearly 2,000 additional tests to better define the characteristics of arc flash events. The updated IEEE 1584 is supported by more testing than any other global standard, and it will be important to understand how the new standard defines the calculated heat energy from a steel mill systems study.

Another great place to start when addressing the risk of arc flash is with the National Fire Protection Association (NFPA) 70E, Standard for Electrical Safety in the Workplace. Although this standard originated in the U.S., many multi-site steel producers have adopted this across their global enterprise. An important addition to the 2018 version is the inclusion of the "Hierarchy of Risk Control." The hierarchy, as described in Table 1, is listed in order from most effective to least effective methods of mitigating risk.[4]

The basic idea of the Hierarchy of Risk Control is that removing the hazard altogether is the best solution and relying on PPE should be the last line of defense. And while hazard elimination via de-energizing electrical equipment is the best method, the equipment will eventually have to be re-energized, so the hazard remains. Therefore, it is necessary to find a different way to reduce the risk. As a result, the industry tends to focus on "engineering controls" to reduce risk to an acceptable level.

Are There Recommended Methodologies for Improving Arc Flash Safety?

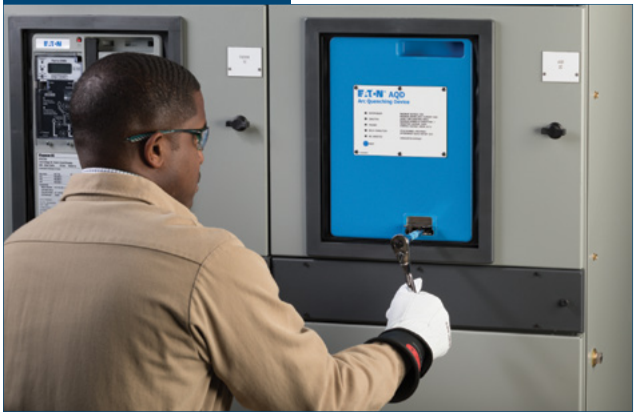
Power management company Eaton and most other suppliers of power distribution and control assemblies have developed a host of solutions to reduce arc flash hazards. Interestingly, many of these can be applied in both new electrical equipment and as a retrofit to support existing equipment. Many of these offerings are

Table 1

Hierarchy of Risk Control

Risk control methods	Examples
Elimination	Conductors and circuit parts in an electrically safe working condition
Substitution	Reduce energy by replacing 120-V control circuitry with 24-VAC or -VDC control circuitry
Engineering controls	Guard energized electrical conductors and circuit parts to reduce the likelihood of electrical contact or arcing faults
Awareness	Signs alerting of the potential presence of hazards
Administrative controls	Procedures and job planning tools
Personal protective equipment (PPE)	Shock and arc flash PPE

Figure 1



An arc quenching system extinguishes an arc flash faster than traditional approaches, reducing the incident energy available.

designed to improve the clearing time performance of the overcurrent protective device, be it a fuse or circuit breaker. Faster clearing times for circuit breakers in low- and medium-voltage switchgear assemblies can significantly reduce the incident energy caused from an arc flash event. Moving workers farther away from the hazard with the addition of remote circuit breaker racking, for instance, also reduces the risk of an arc flash incident. Some newer developments look to be very encouraging as the industry moves toward application of technology to virtually eliminate dangers of arc flash hazards.

Low-voltage arc quenching switchgear provides arc flash protection for workers while performing maintenance or troubleshooting of energized equipment. It can even provide arc protection if breakers are removed, doors are open or panels are removed, and all the while protecting the switchgear itself from arc flash damage. Arc quenching switchgear is tested to the IEEE C37.20.7 test guide and it satisfies the Engineering Controls Risk Control Method as outlined in Annex F of the NFPA 70E – 2018 Edition.

Arc quenching switchgear is able to detect and contain an arc fault in less than 4 ms, drastically reducing the incident energy. It works by detecting the ignition of an arc inside the switchgear using an arc flash relay and transferring the arc to an arc quenching device. Arc quenching switchgear transfers the arc by creating a lower impedance arcing fault, not a bolted fault, safely contained inside the arc quenching device. This reduces the peak fault current by at least 25% and puts less stress on upstream equipment during a quenching operation.

Electrical Safety First

Steel mill owners need to understand the latest regulations, codes and standards focused on arc flash hazards and electrical workplace safety. A good starting point is to ensure site electrical documentation is up to date, and then moving toward completion of a site study to assess the risk. Consideration of critical equipment, equipment maintenance history and age along with identification of areas of the site where energized work is either necessary or should be considered. After the arc flash hazards are identified across the electrical system, owners should align with qualified suppliers capable of performing arc flash calculations (or conducting arc flash studies), recommending system changes and offering technology upgrades that can help mitigate the risk.

References

1. R. Campbell and D. Dini, "Occupational Injuries From Electrical Shock and Arc Flash Events," Fire Protection Research Association, March 2015, www.nfpa.org.
2. Occupational Safety and Health Administration Regulation 1926.960 Subpart (g)(2), 2015 Edition.
3. IEEE 1584 Guide for Performing Arc Flash Calculations, 2002 Edition.
4. NFPA 70E, Standard for Electrical Safety in the Workplace, 2018 Edition. ✦