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How to develop procedures and standards-compliant programs to minimize safety risks.

By Oliver Bojarski, Panduit Corp., and Dan Neeser, Cooper Bussmann

>> The Occupational Safety and Health Administration (OSHA) created standard 29 CFR 1910.147 in 1979, called "The Control of Hazardous Energy (Lockout/Tagout)," which applies in general to industrial workplaces. While many think of electrical energy as the primary type of hazardous energy, it's important to remember that mechanical, hydraulic, pneumatic, thermal and chemical energies commonly are encountered on the job and can be equally as dangerous.

The goal of an effective lockout/tagout program is to control the release of hazardous energies during maintenance and servicing to protect workers and equipment. This article reviews the risks that can be mitigated through responsible lockout/tagout procedures, discusses the ways that standards-compliant programs are developed and implemented, and provides some information on electrical hazards.

The Three Types of Risk

Establishing a strong lockout/tagout program at your facility helps mitigate workplace risks in three ways:

>> Employee safety.
>> Legal risk.
>> Financial risk.

Employee Safety. About 39 million workers are covered under OSHA 1910.147, and about 3 million of these workers face the greatest risk of injury if lockout/tagout procedures aren't properly implemented. OSHA estimates that this standard prevents 120 fatalities and 50,000 injuries annually.

Legal Risk. When evaluating the legal risk, meeting OSHA standards is mandatory. In fact, OSHA's general duty clause clearly states that "each employer shall furnish to each of its employees employment and a place of employment which are *free from recognized hazards.*" This regulation is enforced through approximately 100,000 inspections annually when combining federal and state OSHA site inspections.

Financial Risk. The financial risk associated with not promoting safety through lockout/tagout can be quite high. Not only must personnel and equipment downtime be accounted for, but the costs of legal actions and medical care also can be significant.

Clearly, establishing a comprehensive lockout/tagout program is a wise and far-reaching investment in your company's success.

Elements of Effective Programs

OSHA is the legal standard for workplace safety, and NFPA 70E "Electrical Safety in the Workplace" provides additional details to ensure that the lockout/tagout program is comprehensive. Several mandatory steps must be taken to deploy an effective lockout/tagout program.

The first step is to conduct a hazard assessment by identifying all equipment that is used, serviced, maintained or stored; documenting all energy sources, including the type of hazard, the location on the equipment, proper isolation procedure, and lockout device (see **Figure 1**); and then documenting the methods used to dissipate the stored energy and verify the isolation.

The second step is to develop a detailed written energy control procedure, which contains the information previously identified and also steps to de-energize and re-energize, equipment-specific drawings and diagrams, a list of employees exposed to hazards and qualified to perform lockout/tagout, and the employee in charge of the program.

The third step is to ensure that a robust training program is in place. OSHA mandates that training be given to new employees, employees with new responsibilities or when new equipment is acquired or a change in machines, equipment or processes presents a new hazard or a change in the energy control procedures.

Levels of lockout/tagout training can be split into two employee categories:

- **>> Authorized employees** lockout and/or tagout machines or equipment to perform servicing or maintenance. Their training should make them proficient in recognizing hazardous energy sources, the type and magnitude of energy available in the workplace, the methods and means necessary for energy isolation, control and verification of isolation.
- **>> Affected employees** are all workers who operate equipment which might be locked out/tagged out during servicing or maintenance, or whose job requires them to work in an area in which such servicing or maintenance is being performed. Their training should instruct them in the purpose and use of the energy control procedure while making it clear that they should never attempt to restart or re-energize equipment which is locked out or tagged out, and that warning tags must be respected.

The final step is to perform an annual inspection, which includes both reviewing the company energy control procedure and observing an instance of lockout/tagout in progress.

Electrical Hazards

Three basic electrical hazards exist: shock, arc flash and arc blast. Electrical shock remains a very common and recognized hazard; however, the focus of this article is on the lesser-known hazards of arc flash and arc blast.

The primary hazard from arc flash is the intense heat (temperatures up to 35,000°F) and fire from the arcing fault. Fatal burns can result from this heat, and fire can expand outward up to 10 feet.

Arc blasts can cause high pressures, sound and shrapnel. Pressure can exceed levels that can cause eardrum rupture and collapsed lungs. The sound during an arc blast event can exceed 140 decibels. Shrapnel is the most difficult hazard to predict because every arc blast can present different levels of shrapnel hazards.

About one person per hour over an average 40-hour workweek is admitted into a burn center as a result of an electrical burn. Protective clothing and other personal protective equipment (PPE) are available to help protect against hazards caused by arc flash, but ways to protect against the pressure wave associated with an arc blast are not yet commonly known.

Quantifying the Hazard

The amount of energy from an arcing fault depends on many factors, and the most critical factors include:

- >> Arcing fault current magnitude.
- >> Arc flash duration, or time to clear arcing fault.
- >> Distance to the arcing fault.

The first two parameters depend solely on the overcurrent protective device. The arc flash duration will depend upon the arcing fault current and the time-current characteristics of the upstream overcurrent protective device.

In general, the clearing time of the overcurrent device is the most critical. Delayed tripping as a result of short-time delay settings on circuit breakers with moderate levels of arcing fault currents can result in extremely high arc flash hazards.

In contrast, devices which are current-limiting can greatly decrease the arc flash hazards when the arcing current is in the current-limiting range of the overcurrent protective device (see **Figure 2**).

Both low-arcing and high-arcing currents can be of concern because the combination of arcing current and arcing duration determines the total energy of the arc flash, and therefore the degree of hazard present. In general, the higher the arcing fault current, the faster the clearing of the arcing fault by the overcurrent device; conversely, the lower the arcing fault current, the slower the clearing of the arcing fault.

In some cases, the lower arcing fault currents can result in higher arc flash energies than the higher arcing fault currents. The working distance from the energy source also is important as the arc flash hazard increases exponentially with proximity to the source.

Figure 1. Panduit lockout/tagout solutions are designed to increase safety on the job through systematic energy isolation during the service and maintenance of industrial equipment.

Figure 2. The use of overcurrent protective devices has a strong impact on the magnitude and duration of arc flash faults.

Safety-Related Work Practices

The rule for electrical workers should be "do not work hot." Both OSHA and NFPA 70E require that "hot work" be performed only when absolutely necessary, when de-energizing would be infeasible, or when increased hazards would result.

However, "hot work" cannot be eliminated because workers must test to determine whether voltage is present while establishing a safe work condition.

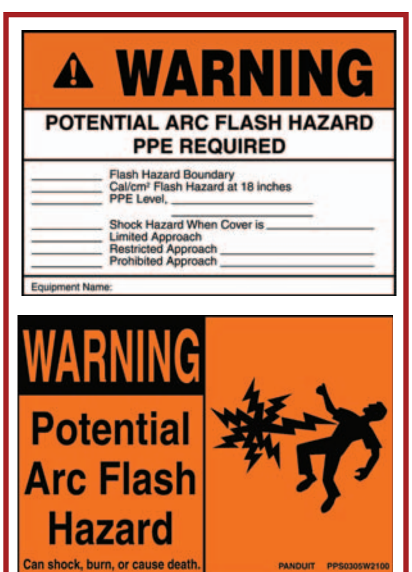

Figure 3. Panduit arc flash hazard labels are available in multiple sizes and versions, including labels with print-on areas for flash hazard boundary, incident energy available and PPE level.

During this time, workers must dress for the hazard and follow procedures as if the power source was energized.

To properly protect the individual, you must determine the extent of the hazard. To do this, NFPA 70E requires both a shock and flash hazard analysis. The shock hazard analysis is based solely on voltage and resulting distances for approach boundaries. In general, only qualified persons can enter these approach boundaries, and they must use appropriate safe work practices when inside these boundaries.

The flash hazard analysis requires you to determine the flash protection boundary (distance at which PPE is required) and the required level of PPE. The flash protective boundary can be calculated or a default value can be assumed if appropriate for the system characteristics. The PPE level can be determined based on calculations of incident energy or the use of "Task Tables" in NFPA 70E; these tables still require knowledge of available fault current and opening time of overcurrent protective device.

Once these boundaries and PPE levels are determined, they must be communicated to qualified persons. Often, the use of labels (examples shown in **Figure 3**) is the best way to identify that a hazard exists and communicate the extent of the hazard.

A Sound Investment

Lockout/tagout is a key part of a complete and effective safety program. While employee safety is a top priority, establishing a comprehensive lockout/tagout program also protects a company from legal and financial risks and is well worth the investment. □

Oliver Bojarski is Business Development Manager for Rockwell Automation® Encompass™ Partner Panduit Corp., Tinley Park, Ill. Panduit offers wiring and communication products, delivering end-to end solutions to support electrical and network infrastructure requirements.

Dan Neeser is Senior Technical Sales Engineer for Rockwell Automation Encompass Partner Cooper Bussmann, a division of Cooper Industries, St. Louis, Mo. The company manufactures circuit protection products globally for the electrical, electronic and transportation industries.

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