CCPS
CENTER FOR CHEMICAL PROCESS SAFETY
An AIChE Industry Technology Alliance

SAFETY ALERT

Control of Hazardous Energy

By Lock-out and Tag-out

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This Safety Alert can also be found on the CCPS Web site at http://www.aiche.org/ccps/safetyalert

The Center for Chemical Process Safety was established by the American Institute of Chemical Engineers in 1985 to focus on the engineering and management practices to prevent and mitigate major incidents involving the release of hazardous chemicals and hydrocarbons. CCPS is active worldwide through its comprehensive publishing program, annual technical conference, research, and instructional material for undergraduate engineering education. For more information about CCPS, please call 212-591-7319, e-mail ccps@aiche.org, or visit www.aiche.org/ccps

Control of Hazardous Energy
By Lock-out and Tag-out

1. Why Lock-Out and Tag-Out?

Lock-out and tag-out (LOTO) is a critical part of a strong all-around safety program. In LOTO, maintenance employees work with production employees to positively prevent all forms of hazardous energy from causing harm.

Hazardous energy comes in many forms. Electrical energy can cause electrocution and burns, provide ignition to flammable atmospheres, and activate mechanical equipment. Steam can cause burns or initiate hazardous reactions. Nitrogen can cause asphyxiation. Chemical flow can cause uncontrolled reaction and injury. When a piece of equipment is being worked on, all sources of hazardous energy must be securely and positively locked out until the equipment is operational.

Untold numbers of major process safety incidents and individual injuries have been caused by failure of LOTO. A prime example is the Bhopal catastrophe, one of the worst incidents ever to have occurred, which was caused in part by the failure of LOTO.

Recently, a company process safety manager called CCPS asking for help in persuading a newly acquired facility within his company to implement a LOTO program. The manager was frustrated because, as the plant director stated, "We understand completely that maintenance workers are endangered if power or material flow were allowed to equipment they are servicing. That's why no one would ever activate a switch or valve during a maintenance activity. LOTO is just extra, unnecessary work."

The company process safety manager knew that with the plant director's attitude, the plant could be on the road to disaster. Could CCPS help him make the case for LOTO?

At CCPS, we firmly believe that it is better to learn from the mistakes of others rather than to learn by painful, personal experience. So we asked CCPS member companies to give us examples of accidents caused by LOTO failures, and to provide testimonials about the importance of LOTO. The purpose of this article is to share this information with you, to help you lead the implementation or improvement of LOTO in your company. A brief overview of LOTO procedures and tools are provided, as are references to more detailed resources.

2. Basics of LOTO

Summarized here are the bare essentials of a good LOTO program. However, we do not intend to cover this topic comprehensively. Readers are urged to become familiar with the more detailed references cited.

To have a good LOTO program:

Do:

Figure 1

- Have a corporate-wide LOTO policy that is mandatory at all sites
- Train affected employees in proper LOTO procedures, and retrain regularly
- Assign authorized employees to ensure that LOTO procedures are faithfully and thoroughly followed
- Identify all sources of hazardous energy potentially impacting a piece of equipment and lock out all sources
- Make sure each person working on a piece of equipment applies his personal lock to the lockout device, as shown in Figure 1.

Figure 2

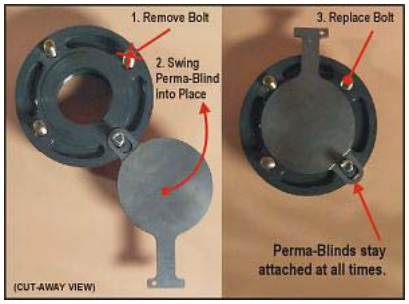
- Apply a tag to the lockout point using a fastener that cannot be easily or accidentally removed. Use a tag that is not easily torn or defaced. (Figure 2)
- Make sure that any stored energy has been released. This includes electrical capacitance, pressure, residual fluids and hazardous atmospheres, and pent up mechanical and potential energy.
- When maintenance activity extends beyond the current shift, replace the personal locks of the leaving shift with the personal locks of the arriving shift. The leaving shift should make sure the arriving shift understands the maintenance process and the hazards
- Once the locks and tags are place, try to operate the equipment to ensure that no lock-outs have been missed
- Locks should not be removed until the maintenance workers and the authorizing employee are satisfied that the equipment is ready to be operated safely

Do not:

- Remove another worker's lock unless the worker is completely unavailable and then only remove the lock after a qualified supervisor has verified that it is safe to remove the lock and authorized the removal

- Assume that a closing and locking a valve is sufficient to prevent flow. The pipe must also be blinded. A cut-away view of one blind arrangement is shown in Figure 3.

Figure 3



- Assume that a piece of equipment has only one electrical source. Often, equipment has two or more – all must be locked out.

3. Learning from Case Histories

Dumb Luck is Never Enough

Many notorious incidents, such as Bhopal, Piper Alpha, Phillips-Pasadena to name a few, were caused in part by failure to perform adequate LOTO. The case histories presented here come from companies with good LOTO programs. They are offered to give you a better understanding of the full range of hazardous energy sources and situations where LOTO is important.

You may get away without using LOTO for some time without getting hurt. Do not let dumb luck fool you into thinking that LOTO isn't necessary:

> *A maintenance technician was investigating a bag-feeding machine because bags were not feeding properly through the roller. He reached into the machine with his left hand while the machine was still running to clear a jam instead, without locking out first. He put his right hand down next to rollers that were running. His right hand slipped into the moving rollers. Investigation showed that all of the operators and maintenance workers routinely reached into the machinery without proper LOTO. He was the one who got unlucky.*

Lock-Out, Tag-Out, and Try-Out

Pay particular attention to the last step in locking out equipment – verify that the residual and stored energy has been released. Remember – Lock Out, Tag Out, and then Try Out. Make sure that you're not surprised by residual energy, as happened in this case:

Workers were attempting to clear a plugged line. The LOTO permit was authorized and locks placed per procedure. Unfortunately, the workers did not verify that all hazardous energy was removed. The residual pressure from blowing out the line remained. As workers opened a flange just below the plug, material was blown out, burning personnel in the immediate area.

Take care when troubleshooting

Sometimes LOTO might seem inconvenient, for example if you need to have parts of a machine or process energized for troubleshooting. In such cases, lock out the process completely, determine which lock-outs need to be removed to do the energized tests, evaluate the potential hazards carefully, and take the appropriate precautions. Only then remove the lock-outs. As soon as the need for the equipment to be energized has passed, the process should be locked out again. Here's what can happen if you forget that last important step:

In a case similar to the one immediately above, a worker was trying to clear a blocked pipe. The LOTO permit was authorized, and all of the required locks were placed according to procedure. The worker opened several valves in an attempt to try to blow it free. This did not work, so he re-closed the valves and reinstalled the lock-outs…except that he missed the valve on the pressurizing line. When the worker opened a flange below the plugged valve, material was blown out, burning the worker.

Hurry up and be late

It's especially tempting to forgo re-locking the system when the job is almost done. Because he was rushing, this electrician arrived home a little later than expected, minus a fingertip:

An electrician troubleshooting a ventilation fan removed lock-outs in order to conduct circuit checks on live circuits. After the circuit check was complete, he continued to work without locking out the power. As he re-installed the belt cover, the fan motor started automatically, catching his hand and cutting off the tip of his finger.

Not all sources of hazardous energy are where you'd expect

Keep in mind that LOTO applies to all kinds of hazardous energy. Remember to look for the obvious – and the not-so-obvious.

LOTO would have prevented several light trucks from being flattened at one site. Each time, maintenance workers neglected to lock out a large excavation vehicle. Fortunately, the trucks were unoccupied. In the slow-moving excavation vehicles, the maintenance workers were unaware that they had driven over the trucks.

Lock-out and tag-out equipment that is out-of-service

LOTO is particularly important when removing defective equipment from service. Lock out and tag out defective and unused equipment until it can be removed or replaced. If you fail to do this, you could repeat one of the following accidents:

- *A worker was electrocuted when he activated a defective, out-of-service electromagnet*
- *One pump of a two-parallel arrangement was out of service but not locked out. Workers, switched to the out of service pump as part of a routine rotation. This resulted in a major process upset costing millions of dollars. Luckily, no one was injured*

Lock-out requires a lock

Finally, never rely on an interlock for LOTO. Make sure you positively lock out all the sources of hazardous energy. This operator wished he'd done it right:

> *An operator needed to clean a mixer. The mixer had an interlock limit switch that prevented the mixer from operating when the lid was up. For protection, the operator propped the lid up and entered (we assume he performed the appropriate confined space entry procedure, but that is a lesson for another day). When the mixer was clean, the operator started to climb back out. As he reached up, his hand touched the lid. This was just enough to clear the 'lid is up' limit switch and deactivate the interlock. Since he had not locked out the power, the motor started. The motion of the mixer caused the operator to fall back inside. When he fell, the lid returned to full-open and the limit switch interlocked the mixer mechanism. However, the mixer made a number of complete revolutions – badly injuring the operator – before coming to a stop.*

4. What Industry Process Safety Leaders Say

The failure to properly use LOTO procedures is one of the most common ways that workers are injured. If you are serious about making your plant safer, make sure you have a well-implemented LOTO program.

> *"I am convinced that one of the most likely ways to severely injure workers is through not using, or not correctly following, safe work practices, including LOTO, Line Opening, Confined Space Entry and Hot Work. This is one of the topics that I stress the most in audits, and I make particular mention of in Process Hazard Analyses. We read about such incidents all the time… For such practices to not be in place is (unacceptable)."*

It is unacceptable for any person to ignore these safety practices because it puts that person at risk and, just as important, indicates that person's willingness to put other colleagues at risk.

> *"Our company standards, including LOTO are REQUIRED for all our sites worldwide. LOTO is one of a few inviolable safety rules that will prompt immediate dismissal from the company if violated."*

Don't forget to consider corporate standards as well as national and local requirements for LOTO. In the United States, OSHA regulations on LOTO are very specific. However, some state regulations may have additional requirements. In Canada, LOTO is covered by various Provincial regulations that vary somewhat. In Germany, only licensed engineers are permitted to lock and unlock electrical equipment. Become familiar with your national, regional, and local requirements. And if you have corporate responsibility for a site that does not have regulations:

> *When no national or local requirement for LOTO exists, Company standards do need to be introduced with sensitivity to culture and with a view to change management. But at the end of the day, safety standards are non-negotiable.*

Above all, if you have responsibilities for operating a plant, become very familiar with good practices for LOTO. Make sure that you and your colleagues go home at the end of the day just as healthy as you were when you arrived.

5. LOTO References:

The following references contain US regulatory requirements. While different regulations may apply to your site, the US OSHA standard and supporting documentation serves as a good reference to LOTO.

1. OSHA Standard 29 CFR 1910.147, http://www.osha.gov
2. OSHA Training for Small Businesses: http://www.osha.gov/SLTC/smallbusiness/sec11.html
3. NIOSH Guidelines for Lock-out Tag-out: http://www.cdc.gov/niosh/83-125.html
4. CCPS, "Guidelines for Process Safety Documentation" pp 307-309, American Institute of Chemical Engineers 1995, http://www.aiche.org/pubcat, publication G-27
5. Oklahoma State University Lock-out Tag-out Program, http://www.pp.okstate.edu/ehs/manuals/Lock-tag.htm

Acknowledgements

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