TRAINING AND QUALIFICATION PROGRAM OFFICE BROOKHAVEN NATIONAL LABORATORY	Course Code: OSH151C Control No.: 01 Revision No. 0

LOCKOUT / TAGOUT STUDY GUIDE

Lockout/Tagout

Study Guide

for the

Challenge Exam

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LESSON OBJECTIVES

TERMINAL OBJECTIVE: Describe controls and individual responsibilities for Lockout/Tagout per ES&H Standard 1.5.1.

ENABLING OBJECTIVES:

EO-001. Explain the purpose of the Lockout/Tagout program.

EO-002. Name seven sources of energy.

EO-003. Define the requirements for an Affected Employee.

EO-004. Define the requirements for an Authorized Employee.

EO-005. State BNL's Energy Control Procedure.

EO-006. Describe verification of isolation.

EO-007. List personal protective equipment requirements.

EO-008. State the steps confirming zero energy state.

EO-009. Identify the type of instruments used to test for voltage, pressure/vacuum and temperature.

EO-010. Explain release from Lockout/Tagout.

EO-011. Describe LO/TO in progress.

INTRODUCTION

What is Lockout/Tagout (LO/TO)?

EO-001 Explain the purpose of the Lockout/Tagout program.

Lockout/Tagout is the practice or procedure necessary to disable machining or equipment and to prevent the unexpected release of potentially hazardous energy during maintenance servicing or construction (NOT TO PREVENT NORMAL USE). If normal use is to be prevented, then yellow caution tags may be employed for administrative control

Note that the standard specifies the unexpected release of potentially hazardous energy. It is not restricted to electrical energy, although this represents a large percentage of lockout/tagout applications. However, it refers to seven different sources of energy, as defined later in this document

Accident Statistics

From October, 1994 through March, 1996, 78 events that involved electrical shock (or potential for electrical shock) were identified during the review of ORPS Occurrence Reports generated during this time period. From 1983 to 1992 approximately 130 DOE or DOE contractor personnel reported shocks or bums from electricity in the workplace and electrocutions killed four people at DOE sites during these years. Inappropriate lockout/tagout procedures was the reason for many of the occurrences. Failure to control energy caused 10% of the serious accidents. Analysis has shown that the Root Cause for many of these occurrences was lack of training in de-energizing machinery or equipment or failure to consult a schematic or a print.

OSHA's research for the Lockout/Tagout Standard revealed that the number of accidents peaked 15 months after training, indicating that retraining should occur annually. OSHA requires retraining for all authorized and affected workers whenever there is a change in their job assignments, a change in machines, equipment or processes that present a new hazard, or when there is a change in the energy control procedures. Additional retraining shall also be conducted whenever a periodic inspection reveals or whenever the employer believes, that there are deviations from or inadequacies in the employee's knowledge or use of the energy control procedures.

When should you lock or tag out?

Lockout/Tagout is necessary whenever you are performing service, maintenance, or construction around any machine where you could be injured by:

- Unexpected start-up of the equipment
- Release of stored energy

Two situations are most likely to need lockout/tagout:

- When you must remove or bypass a guard or other safety device
- When you must place any part of your body where you could be caught by moving machinery

In other words, you must remove energy flowing to a device and/or release or secure energy stored within the device in order to bring it to a "zero energy state."

Sources of Energy
EO-002 Name seven sources of energy

Energy is movement or the inherent potential for movement. Whether the power switch is on or off, energy of some sort is usually present in any powered equipment. Energy can come from many different sources, but it is always one of two types:

- Kinetic energy - the force caused by the motion of an object

- Potential energy - the force stored in an object that isn't moving

CAUTION

Make sure that an individual trained in the proper use of the appropriate test instrument checks the components or circuits to verify isolation before work is started.

Electricity

There could be many sources of electrical energy to a device. **Check schematics to determine if you have located ALL sources and controls.** Ensure that your schematic reflects the latest modifications or updates. Be sure to isolate ALL energy sources - secondary power supplies as well as the main one.

If the source of power, such as a plug, is under your exclusive control (in your sight) then LO/TO is not necessary.

If working with capacitors, ensure they have been isolated from the energy source and have been discharged and are shorted before working on them. Consider the time constant if working on a RC circuit.

Warning - If not shorted or grounded, capacitors may recharge through dielectric absorption or from corona effect if next to a charged capacitor. If stored energy can re-accumulate; you must monitor it to make sure it stays below hazardous levels.

Inductors store energy as current. Small inductors normally discharge rapidly, except in the case of supercooled inductors. Consult the operating specifications before working on supercooled inductors.

Mechanical

Avoid exposure to rotating equipment, especially after machine guards have been removed. Inspect the system to make sure all parts have stopped moving. A spring under tension may store a tremendous amount of potential energy. Be sure to block any spring driven mechanical motion or relieve tension stored in springs.

If working on an automatic machine, make certain the sensing circuits have also been deactivated.

Chemical

Avoid exposure to large quantities of chemicals and fumes such as caustics or acids, especially when opening vats or tanks or when disassembling chemical transfer lines.

Transfer of chemicals also provides exposure to chemicals from splash. Use the proper procedures for transferring as well as personal protective equipment.

Stored energy may occur in chemical form. If gasoline is ignited, it changes state and creates a physical hazard from the heat and pressure. The energy in one gallon of gasoline is approximately equal to the energy in one stick of dynamite.

Hydrogen, used for many purposes around the Laboratory, will present an explosion hazard when mixed with oxygen. When purging hydrogen lines, make sure there are no ignition sources in the area.

Thermal

Exposure to temperatures above 113°F or below 39°F requires personal protective equipment and/or proper handling techniques. Some examples of hazards would be exposure to heating elements such as from soldering irons or heat guns; open flames such as used in oxyacetylene burning and welding operations; or burners used in laboratories. Flames that are colorless and are hard to see, such as from an alcohol burner might present a greater hazard.

Cryogenic fluids, such as liquid nitrogen, helium, oxygen, air, methane and hydrogen are used in the Lab. Hazards of working with cryogenic fluids include cold injury, burns, phase changes, oxygen deficient/enriched atmosphere, fire/explosion and acute respiratory problems.

Stored heat or cold is a hazard. Insulated tanks retain their extreme heat or cold that must be dissipated prior to working on them. If that cannot be done, then personal protective equipment such as gloves must be used.

Hydraulic

Pressurized hydraulic systems are operating at increasingly high pressures. Some systems operate at pressures that could drive fluid through a person's skin and into their bloodstream resulting in blood poisoning. Before working on hydraulic systems:

- Relieve the trapped pressure.
- Block parts in hydraulic systems that could move from loss of pressure.
- Drain process piping system and close valves to prevent the flow of hazardous materials.
- If a line must be blocked where there is no valve, use a blank flange.
- Purge reactor tanks and process lines.

Pneumatic

Pressurized air systems may contain tremendous energy. The hazard is so great that we restrict compressed air for general shop or laboratory use to a maximum pressure of 30 psig using restricting nozzles. Air, at higher pressures may penetrate the skin resulting in an embolism. Compressed air at full line pressure of up to 100 psig without restricting nozzles, may be used to operate pneumatic tools and certain control instruments.

Potential

From basic physics, a weight (pounds) raised to a height (feet) will store potential energy which we measure in foot pounds - (ft/lbs). Block or brace parts that could fall because of gravity.

Stored energy may also be found in springs under tension. Release the tension on springs or block the movement of spring driven parts.

Multiple Energy Sources

Complex machines such as aircraft or electric trains have multiple sources of energy. The large machines at the Lab, such as AGS, Reactor, NSLS and RHIC also have multiple sources of energy. These machines have every source of energy that was just discussed.

Stored Energy

This energy must be released or secured in order to bring the device that maintenance or servicing is going to be performed on to a "zero energy state".

BNL Lockout/Tagout Requirements
EO-003 — Define the requirements for an Affected Employee
EO-004 Define the requirements for an Authorized Employee

Affected Employee

The job may require an Affected Employee to operate or use a machine or equipment on which maintenance, servicing, or construction is performed under lockout or tagout, or to work in an area where these activities are performed.

An "Affected Employee" must be able to recognize when the energy control procedure is being implemented and to identify locks and/or tags used in the Laboratory LO/TO Program. Affected Employees must understand the purpose of the procedure and realize that if they remove or attempt to bypass locks or tags or attempt to start up or use equipment that has been locked and/or tagged out, they may injure or kill the person performing maintenance on the equipment. Therefore, they shall never defeat the LO/TO system. **Anyone** who does defeat the system will be subject to disciplinary action.

Authorized Employee

An Authorized Employee is an employee who is permitted by the Laboratory to implement a lockout and/or tagout procedure on machines or equipment to perform maintenance, servicing, or construction on that machine or equipment. An Authorized Employee is trained to recognize hazardous energy sources, the type and magnitude of the energy available in the workplace, and the methods and means necessary to isolate and control the energy source. The authorized employee equates to OSHA's definition of "qualified," in that this person is trained to implement the lockout/tagout and perform service.

BNL defines **two** classes of "authorized employees".

1. **"Knowledgeable Employee"** - A knowledgeable employee is a person whose name is carried on a Departmental list as having received formal course work in lockout and tagout, and formal training or documented "hands-on experience" in safety-related technical aspects of the equipment. These Knowledgeable Employees are authorized to LO/TO primarily for their own safety while performing servicing and maintenance activities. The authorization of these employees to conduct lockout/tagout is limited in that they cannot install "group locks or operations locks and/or tags." However, they are authorized to attach additional locks and tags in "operations lock" situations provided that their lock and tag is **not the first applied or the last one to be removed.** All supervisors must qualify at least at the "Knowledgeable - Authorized Employee" level for lockout and tagout work.

2. **"Responsible Employee"** - A responsible employee is a person whose name is carried on a Departmental list as having received formal course work in lockout and tagout, and formal training or documented "hands-on experience" in safety-related technical aspects of the equipment. They also have been trained to **exercise group and system-level judgments.** These employees are authorized to lockout and tagout any equipment for which they have departmental approval. If coordinated multiple lock and tags are applied by more than one employee; those of the "Responsible Employee" must be the first to be applied and the last to be removed.

It is **desirable** for line supervisors to be trained to the "Responsible Employee" level and **act in that capacity.**

Personnel trained solely to the level of this course are NOT permitted to lock and/or tag without additional training and the authorization of their department.

BNL shall certify that employee training has been accomplished and is being kept up to date.

BNL's Energy Control Procedure
EO-005 State BNL's energy control procedure

Communication is extremely important in LO/TO. The "Authorized Employee" **shall** notify "Affected Employees" before controls are applied and after they are removed.

Application of control

Before starting work, the "Authorized Employee" shall physically locate all energy-isolating devices using schematics or prints as necessary. Before you turn off any equipment in order to lock or tag it out, you must know the types and amounts of energy that power it, the hazards of that energy, and how the energy should be controlled. Shut the system down by using its operating controls. Follow whatever procedure is specified for the equipment so that you don't endanger anyone during the shutdown.

De-energized **ALL** power sources and safely disconnect all appropriate mechanical linkages. Be sure to isolate **ALL** energy sources - secondary power supplies as well as the main one. Be sure you never pull an electrical switch while under load and never remove a fuse instead of disconnecting. Document all lockouts and tagouts in a bound logbook.

If the equipment can be locked out, do so with a BNL dedicated red-banded Master lock and where appropriate, place a red HOLD tag. If the equipment cannot be locked out, it must be tagged out. Tag the equipment with a red HOLD tag. These locks and tags are to be used for LO/TO and not for anything else.

Use a lockout device if your lock cannot be placed directly on the energy control. When lockout is used, every employee in the work crew must attach his personal lock. More than one employee can lock out a single energy-isolating device by using a multiple lock adapter. For big jobs, a lockout box can be used to maintain control over a large number of keys.

If you cannot lock the device out, then tag it out and also disable and label a supplemental device to render the system safe. An example of supplemental devices include the use of lockout tape, removal of an isolating circuit element, blocking of a controlling switch, removing a valve handle, inserting a blank flange, or opening an extra disconnecting device. The idea is to bring the tagout to the same level of safety as lockout. Locate the HOLD tag at the same location or as close as possible to the control device using a non-reusable nylon cable tie with an unlocking strength of not less than 50 pounds. Make sure the tag is filled out legibly and correctly.

Work on cord/plug-connected electrical equipment is made safe by unplugging the equipment cord. This method may ONLY be used if the plug is within sight and under your exclusive control. For this situation, no LOTO is required.

The main energy source controlling a device must be disconnected, locked and where appropriate, a tag placed. If a group lock is used, it shall be locked and tagged. If you are working on equipment installed before January 2, 1990, a provision to attach a lock was not a requirement and you may not be able to attach a lock. If locking is not possible, tag and use a supplemental means of protection.

All potentially hazardous stored or residual energies shall be relieved or otherwise rendered safe.

If more than one employee is working on the equipment, then more than one lock/tag should be attached. One man - one lock/tag. OSHA requires that the tagout tag stub must be returned for data entry in the Tag Logbook, no later than the end of the "authorized employee's" shift.

Verification of Isolation

EO-006 Describe verification of isolation
EO-007 List personal protective equipment requirements
EO-008 State the steps confirming zero energy state
EO-009 Identify the type of instruments used to test for voltage,pressure/vacuum and temperature

Before starting to work after locking and tagging out, the "Authorized Employee", trained on the proper test equipment, SHALL verify that the equipment has been isolated and de-energized. Make sure all danger areas are clear of personnel.

Pressure

When testing for pressure, use the appropriate gauge for the medium being tested as well as the appropriate scale, e.g. lb/in^2 psig, etc. When testing for vacuum, use an appropriate gauge with a scale marked in inches of Mercury (in. Hg.). For low pressure it may be appropriate to loosen flange bolts and slightly separate a flange joint, but only if there is no danger of exposure to a hazard. A more appropriate method is to open test fittings or drain valves, which will assure that the pressure is relieved. It is recommended that drain valves be left open to prevent re-accumulation of pressure.

Temperature

Many systems that are maintained in the Lab may operate at extremely high or low temperatures. Allow them to return to room temperature before working on them.

If the systems or devices have temperature-measuring instruments installed, use them. If there is no installed instrumentation, you may use various devices to find the temperature. Some devices are:

- Pyrometric sticks - These are crayon-like sticks that can be marked on a surface. The wax material will melt if the temperature is within 5° of the specified stick temperature.
- Thermometers - A contact type fast response thermometer is a quick and easy way to get a reading.
- Pyrometers - Point and shoot method is easy for high temperature objects.
- Infrared heat detectors - Point and shoot method with a wide temperature band.

Electricity

If the circuit you are testing has a voltage greater than 50 Volts; with greater than 10 milli-Amperes of available current or capable of instantaneous release of 10 Joules or more of energy, you may be working hot and need a Working Hot Permit.

When testing for electricity, use a voltmeter that your Department/Division has approved.

The procedure for verifying an electrical circuit is de-energized is as follows:

1. Ensure that the disconnect switch or circuit breaker is in the OFF position. Verify that the equipment is isolated or de-energized.
2.
2. When turning a disconnect OFF, keep your face away from the cover of the box. Arc explosions have occurred, resulting in the cover being blown off or open with a

fireball burning the worker. Use your left hand and keep your face away from the box except when the box is in a corner to your right. In that situation, use your right hand, but make sure that your face is away from the box.

3. Identify the voltage range of the circuit to be tested and select a meter appropriate for that range. If your Department/Division specifies the meter to be used, comply with that directive.

4. Use personal protective equipment that your Department/Division approves. Always wear safety glasses for verification of electrical isolation. While a hard hat is not mandatory, you may consider wearing one if your head is near grounded or energized devices.

5. When opening the cover on the box, consider that all electrical components are energized until proven otherwise.

6. Observe that all contacts have opened. A disconnect is a mechanical device, and they have been known to fail. Look at the switch blades to ensure all have pulled out.

7. Observe the location of the grounding terminal(s) in the box. Attach grounds as appropriate.

8. If your meter has a selector switch, set it to the appropriate scale; Volts AC or DC.

9. Place the **red** (positive) probe in the holder on the meter.

10. Test the meter on a known energized source, preferably in the voltage range to be used, to ensure the meter is working.

11. Place and hold the **black** (negative) probe on the grounding terminal in the box.

CAUTION

A disconnect switch may be wired backwards, the line connected to the load side and the load connected to the line side - assume nothing.

12. Test for voltage on each phase of the line side by touching the **red** (positive) probe to each terminal (all three if three-phase). If testing single-phase two wire circuits, determine the wire supplying power. For single-phase three wire circuits, determine the two wires supplying power. In any case, make sure the voltage displayed is in the correct range.

13. Test for voltage on each wire of the load side by touching the **red** (positive) probe to each terminal. For multi-phase circuits, ensure that phase-to-phase readings are also zero volts.

14. Perform an additional test downstream of the disconnect on the load side. "Sneak circuits" have been discovered in a number of devices on site.

15. Test the meter again on a known energized source to verify its operation. It could have malfunctioned since first checking it.

16. If there is any chance of re-accumulation of energy, you must address it by shorting components and/or continually verifying that there is isolation and no accumulation of energy.

17. Verify that the device is inoperative. Check that there is no exposure to personnel, press all start buttons and operate normal controls on the equipment itself. When operating toggle switches, be sure to return them to the OFF position to ensure that the machine does not re-start when power is restored.

Performing the work

Look ahead, and avoid doing anything that could re-activate the equipment. Don't bypass the lockout when putting in new piping or wiring.

Release From Lockout/Tagout
EO-010 Explain release from lockout/tagout

Before lockout/tagout devices are removed and energy restored, the authorized employee shall inspect the area for foreign objects and debris. Assure that the machine or equipment is operationally intact. Remove all tools and make sure all guards are in place. Check the work area and other areas. If the equipment being energized may introduce additional hazard into another work area, you want to be sure all potentially affected personnel are clear prior to startup. Notify everyone who works in the area that lockout/tagout is being removed. It may be necessary on a complex job to conduct a head count to make sure everyone is clear of the equipment. The HOLD tag and/or lock can only be removed by the individual(s) who attached it(them). The last lock and tag is removed by the Authorized Employee who first attached it.

When the worker who applied a lock isn't there to remove it, the lock can be removed only in an emergency situation or when work is completed on a different shift.

The procedure to use for an emergency is as follows:

- Verify that the authorized employee who applied the device is not at the facility. Try to contact the absent employee by paging and attempting to reach the employee at home.

- Properly remove the lock and/or tag using steps outlined in Section 5.0, of BNL's Lockout/Tagout Standard. The removal shall be documented in the organization's LO/TO Logbook.
- Ensure that the authorized employee has been informed that his or her lockout device was removed before he or she resumes work.
- Notify that person's supervisor that the employee's tag or lock was removed! If possible, do so before the start of that supervisor's shift. Place a written notice at the employee's workstation and verbally notify the employee's coworkers.

Return the HOLD tags and locks at the end of the job, and make the appropriate notations in the logbook. Follow a checklist of required steps to re-energize the system. Safe work procedures suggest an operational check of an entire system, even if the equipment placed under LO/TO was only a part of it.

Recognize Lockout/Tagout in Progress
EO-011 Describe lockout/tagout in progress

Locks - BNL Stock Number L 65054

The locks utilized in the Lab are Master locks with a red band around the bottom.

Tags - BNL Stock Number S 81045

The tags used in the Lab are red HOLD DANGER DO NOT OPERATE tags.

Labels - BNL Stock Number S-33780

The labels used in the Lab have an adhesive back that may be taped over switches or circuit breakers.

Cable Ties - BNL Stock Number A-59842

These cable ties meet the OSHA requirements for non-reusable fasteners with minimum pull strength of 50 pounds.

Accountable Key Systems

Key systems or "Kirk" key systems have to be certified to provide protection equivalent to lockout/tagout. If the system does not provide that protection, then lockout/tagout must also be used whenever more than one employee is performing maintenance. Affected employees shall remain clear of any system with the Kirk key removed. Department/Division specific training is required for key systems.

Special Situations

Be alert for new types of lockout or tagout devices when outside contractors are performing service or maintenance at your worksite.

If you must temporarily reactivate equipment you are working on:

- Remove unnecessary tools from the work area and make sure everyone is clear of the equipment.
- Remove lockout/tagout devices conforming with Release From Lockout/Tagout and re-energize the system.
- As soon as the energy is no longer needed, isolate the equipment and reapply lockout/tagout, in accordance with BNL's Energy Control Procedure and Verification of Isolation.

For further information of special situations, refer to the examples in the Lockout/Tagout Requirements in ES&H Standard 1.5. 1, Appendix A.